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MACKENZIE VALLEY PIPE LINE TERRAIN INVESTIGATION 1970

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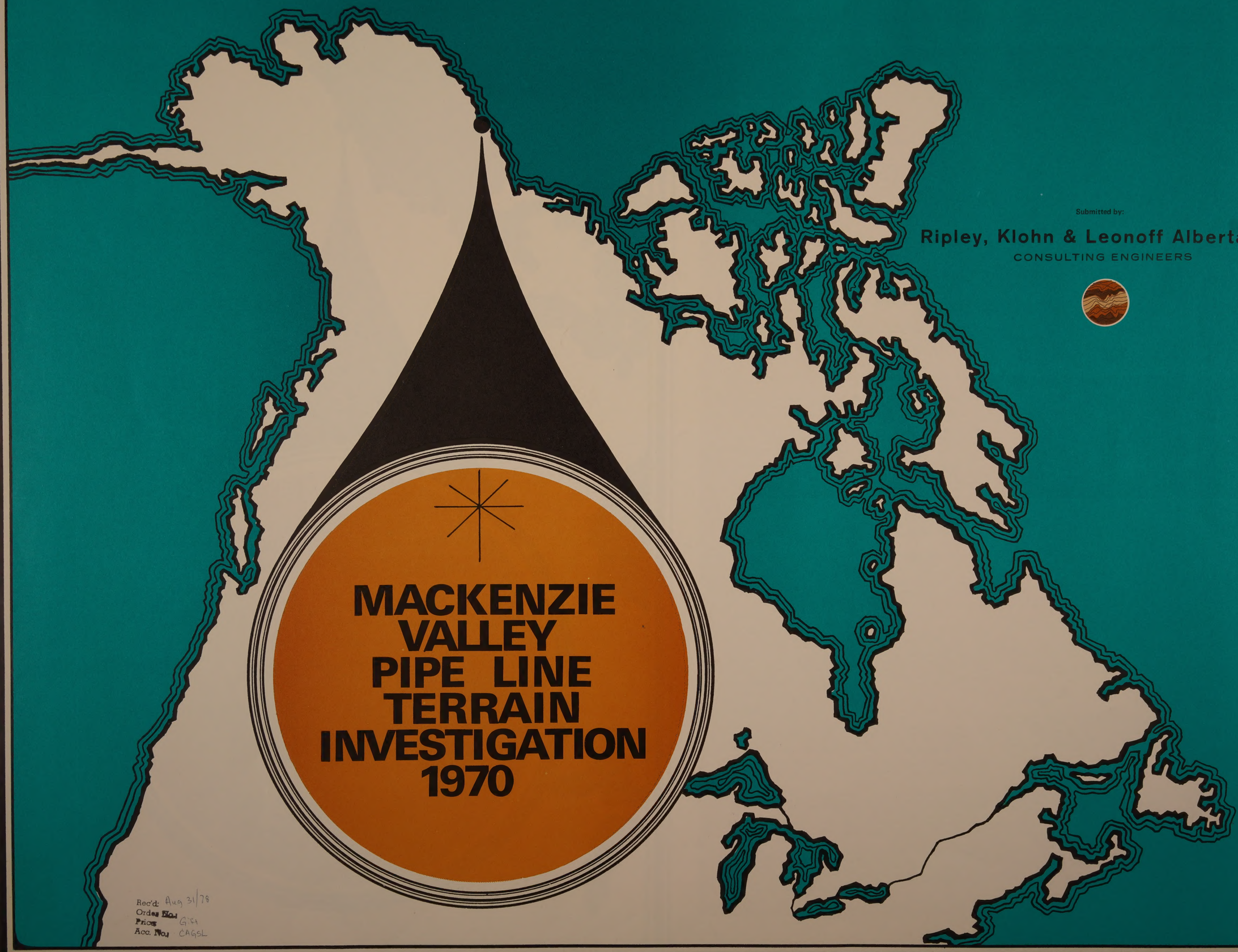

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Ripley, Klohn & Leonoff Alberta Ltd.

CONSULTING ENGINEERS

MACKENZIE VALLEY PIPE LINE TERRAIN INVESTIGATION 1970

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MACKENZIE VALLEY PIPE LINE TERRAIN INVESTIGATION 1970

PRUDHOE BAY ALASKA VIA THE PORCUPINE RIVER
TO THE NORTHWEST TERRITORIES / ALBERTA BORDER

FOR

MACKENZIE VALLEY PIPE LINE RESEARCH LTD.

Submitted by:

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER CALGARY EDMONTON REGINA WINNIPEG

FOREWORD

GEOTECHNICAL DATA

This data report is a compilation of geotechnical information obtained from a three month field program of reconnaissance and exploratory drilling along a proposed route for an oil and/or gas pipeline. The program was carried out in 1970 by two consulting engineering firms, J. D. Mollard and Associates Limited and Ripley, Klohn & Leonoff Alberta Ltd., working co-operatively on behalf of Mackenzie Valley Pipe Line Research Ltd. Drilling and transportation contractors were Big Indian Drilling Limited and Klondike Helicopters Limited of Calgary, Alberta, respectively.

The investigation undertaken was over a distance of 1200 miles from Prudhoe Bay, Alaska, to the Northwest Territories – Alberta Boundary at approximately longitude 119° 00'. The route skirts the west and south side of the Alaska Wildlife Range; crosses the Yukon Territory on the north side of the Porcupine River; passes south of Fort McPherson; and follows the Mackenzie Valley from Sans Sault Rapids to Fort Simpson. Between Sans Sault Rapids and Fort Simpson, alternate routes on the east and west sides of the Mackenzie River were investigated.

PROGRAM

The 1970 program was a continuation of preliminary field and office studies carried out in 1969 by the two consulting firms, who were then working separately for independent clients. In 1969, J. D. Mollard and Associates Limited carried out a preliminary terrain analysis based on an office study of high-altitude aerial photographs for the Northwest Study Group, who are studying a gas pipeline. In 1969, Ripley, Klohn & Leonoff Alberta Ltd. participated in a field drilling program and office air-photo interpretation for Mackenzie Valley Pipe Line Research Ltd., for an oil pipeline along the Alaskan North Slope and Yukon coast and southward across the Mackenzie River drainage basin. In 1970, the two firms were requested to work co-operatively on a continued program of field work and office studies.

The field work consisted of test hole drilling and/or reconnaissance observations at about 300 pre-selected points along the potential pipeline route. Test hole drilling was carried out at about 200 of the 300 points. The holes were 4 inches in diameter and ranged in depth from 20 to 60 feet. Reconnaissance observations at many points were made in addition to those that had been pre-selected. Transportation of men and equipment was carried out entirely by helicopter.

The planning and execution of the program proceeded through six distinct phases as follows:

- Preliminary office interpretation of terrain types along the route investigated using existing high-altitude airphoto coverage at a scale of 1 inch = 5280 feet and 1 inch = 3300 feet. This study was made by J. D. Mollard and Associates Limited, Regina.

- Assembly of strip photomosaic worksheets by J. D. Mollard and Associates Limited. These worksheets showed the original preliminary terrain typing from Prudhoe Bay, Alaska, to Sans Sault Rapids, N.W.T., and from here along the west side of the Mackenzie River Valley to Fort Simpson, N.W.T.

- Assembly of strip photomosaic sheets reduced from photomosaics prepared by J. C. Sproule and Associates Ltd. in 1969. Photogeological interpretation by J. C. Sproule and Associates Ltd. was carried out on a broad regional basis, indicating the general soil and rock conditions that might be expected. No attempt has been made to correlate the airphoto interpretation carried out by J. D. Mollard and Associates Limited and J. C. Sproule and Associates Ltd.

- Selection of individual test sites for drill holes and field reconnaissance observations based on preliminary airphoto interpretation studies. This phase of planning the field program was carried out by J. D. Mollard and Associates Limited in consultation with Ripley, Klohn & Leonoff Alberta Ltd.

- Organization, arrangement and execution of the field program in the period August 10, 1970, to November 11, 1970, by Ripley, Klohn & Leonoff Alberta Ltd. in consultation with J. D. Mollard and Associates Limited, Regina.

- Compilation and presentation of data gathered by Ripley, Klohn & Leonoff Alberta Ltd. in consultation with J. D. Mollard and Associates Limited.

OBJECTIVE

The objective of the 1970 terrain investigation program was two-fold: first, to add to existing basic information on subsoil and permafrost conditions along the potential pipeline route; and, second, to improve the level of confidence in follow-up airphoto interpretation work by providing known field data at selected points. These data, collected at selected points in the field, would be used to correlate actual field terrain conditions with those interpreted from the airphotographs. The correlations made at selected test sites could then be extrapolated to adjoining areas using photo-interpretation as the tool to do this.

APPROACH

The permafrost terrain of Alaska and Northern Canada present unique and unprecedented problems for pipeline construction and maintenance. Knowledge of the subsurface conditions in these areas is sparse. Acquisition of relevant information is therefore required to obtain a clearer picture of the conditions to be dealt with.

Because of the great variability and complexity of terrain conditions along the 1200 mile route, the investigative problem called for gathering of the desired information in a well-organized and efficient manner.

Two basic approaches to gathering the desired information would be: 1) to carry out a massive drilling program with drill holes spaced relatively close together; 2) to carry out a selective drilling and reconnaissance program with the location of test sites based on existing knowledge of geotechnical and permafrost conditions supplemented by the interpretation of available aerial photographs. The amount of drilling required in the first alternative would amount to several times that involved in the second alternative in order to obtain the same information.

The second approach involves successive steps in the process of gathering, sorting, and evaluating information, each step involving closer evaluation and greater refinement. This approach necessitates a system for the grouping of surface, subsurface, and permafrost features and conditions into different terrain types, that can be recognized in aerial photographs with a reasonably high level of confidence. The guiding philosophy used in this investigation is based on three premises:

- for pipeline-engineering purposes, the simplest method for initial grouping of the terrain conditions is based on the airphoto recognition of geological landforms and depositional environments of unconsolidated sediments.

- the accuracy and level of confidence of the terrain typing based on the interpretation of aerial photographs depends, among other factors, on the number and characteristics of sites at which predicted and actual field conditions are positively correlated.

- the locations of drillholes and reconnaissance points selected for field investigation should provide basic information on soil and permafrost conditions typical of individual terrain types that are mappable from an office airphoto study. The decision as to number of sites required for this stage of the investigation was made with a view to obtaining an improved level of confidence in the interpretation of terrain types and conditions from aerial photographs.

FIELD PARTY

Project co-ordinator	–	Executive engineer
Party chief	–	Senior engineer
Drill inspectors	–	Senior engineers and technicians

EQUIPMENT

Helicopters	–	Bell 206 (capacity 4 persons) for reconnaissance Bell 205 (capacity 14 persons) for airborne movement of the drill and crew
Drill	–	Airborne rotary drill using compressed air as the drilling fluid

PROCEDURES

Reconnaissance	–	Observation of vegetation, logging of surface soil and rock exposures and drill hole siting
Drill holes	–	Four inch diameter holes, generally drilled to 20 feet with a maximum depth of 60 feet
Samples	–	Obtained at 2, 5, 10, 15, and 20 feet and at every 10 feet thereafter using a split-barrel sampler
Tests	–	Water content, Atterberg limits, grain size, bulk density, specific gravity, and organic content.

TERMINOLOGY

The data have been gathered and presented by geotechnical engineers with a view to providing a reservoir of data, capable of interpretation by specialists in other disciplines concerned with the pipeline study, such as geologists, botanists and ecologists, among others. The large amount of information obtained has dictated the use of simple commonly used terms. Those terms are thought to be understandable to both the general reader and to the specialist. Attention is drawn to the usage of the following terms:

"Grass" is used as a general term to refer to all grass-like plants, even though these plants in the wet Arctic environment are predominantly sedges.

"Hummocks", "tufts", and "tussocks" are used more or less synonomously and interchangeably.

"Shale" is used as a general term to encompass not only shale itself but such allied rocks as claystones, siltstones, mudstones, argillites, and some argillaceous fine-grained sandstones.

"Sandstone" is used as a general term to encompass such varieties of sandstone as greywacke, arkose, quartzitic and quartzose sandstones.

"Till-like" is used to refer to mixed-grained soils where the identification of till was not positive and was difficult to make.

"Esker-like" is used to refer to ridges of fine sand where there was doubt whether the land form was a long sand dune or an esker.

EVALUATION

This report presents a compilation of basic data on soil and permafrost conditions determined from the 1970 terrain investigation. No evaluation of the data is attempted here. Together with new low level aerial photography these data should provide a sound basis for evaluation of conditions and pipeline problems by the two consulting engineering firms and will be the subject of subsequent reports.

AUTHORIZATION

Authorization to carry out this program was received verbally from the Technical Committee of Mackenzie Valley Pipe Line Research Ltd. on August 7, 1970 and was confirmed in a letter from Mr. E. D. Wilson, Research Co-ordinator, on August 12, 1970.

E. W. Speer, P. Eng.
Manager
RIPLEY, KLOHN & LEONOFF ALBERTA LTD.

ROUTE & INDEX LOCATION MAP

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation

SUBMITTED	DATE	SITE No.
R Jewell	Dec/70	
APPROVED	DATE	SHEET No.
Culpeper	Dec/70	

DESCRIPTION OF SURFICIAL DEPOSITS, TERRAIN, AND PERMAFROST CONDITIONS SHOWN ON ACCOMPANYING MOSAIC WORK SHEETS INTERPRETED PRIOR TO FIELD SURVEYS IN 1970

MAP SYMBOL

SSD Stabilized sand dunes. Fine sand and silty sand in narrow low ridges.

AFP Active flood plains. Braided streambed deposits of sand, gravel, and cobbles generally becoming coarser upstream. These coarse granular deposits appear whitish on airphotos. Depth to the permafrost table varies with latitude and mean annual air temperature, and may be only a couple of feet below streambeds crossing the Arctic North Slope. In general the active layer becomes increasingly thicker in a southward direction. These coarse stream-channel deposits represent potential sources of granular construction materials where they are unfrozen.

FFP "Fossil" (i.e., inactive) flood plains including low alluvial terraces. Faintly braided in appearance in the case of large gravel-bearing rivers crossing the Arctic North Slope. Includes non-braided portions (overbank deposits) of flood plains adjoining large meandering rivers, islands in the active flood plain of large braiding rivers, as well as narrow to wide strips of fossil flood plain and low alluvial terraces adjoining the active flood plain of braided rivers. Expect thin peat and ice-rich organic silt over stratified sand and gravel. Also, expect thicker peat and ice-rich silt in FFP areas showing thermokarst features. Depth of ice-rich peat and organic silt over stratified sand and gravel is usually less than 5 feet and seldom over 10 feet where FFP adjoins AFP. Permafront table varies with latitude.

AMP Active meander plains. Typically this unit consists of a narrow serpentine channel with exposed granular pointbar deposits bordered by wider inactive flood plains showing oxbows and meander scrolls. Locally meandering river may undercut bedrock, till, sand and gravel, or silt bluffs. The stream channel width is usually much narrower than it is in AFP or FFP and rarely covers the entire valley floor. AMP may include both active and inactive portions of the flood plain of meandering streams. Expect variable ice content with a thicker surface layer of silt and sand below the inactive floodplain portion.

HT High terraces. These terraces may be either erosional benches cut in lacustrine or eolian silt or depositional (alluvial, fluvial) terraces and contain variable proportions of silt, sand, and gravel.

ACP Arctic coastal plain. Notably less patterned terrain as expressed on 1 inch = 1 mile airphotos. Land surface appears slightly elevated and better-drained on high-level aerial photographs. Relatively fewer ponds and oriented lakes. Occurs in association with map-units IWP, SOL, and FOL. Expect mainly thin (averaging about 5 feet) ice-rich peat and organic silt over bedded silty sand and gravel strata.

RSR Rolling smooth regions characterized by streaked silt-mantled slopes commonly found in foothill regions. This map-unit is also characterized by extensive downslope sheetwash and rill erosion in continuous permafront regions. Expect mainly thick (commonly up to 30 feet in depressions, thinner on ridges) ice-rich surficial silt deposits over a) Tertiary sand and gravel, b) sandstones, shales and other bedrocks, c) silty to sandy till moraine, d) glacial outwash sand and gravel, and e) large granular alluvial-fan deposits. Surface deposits are thought to be composed mainly of loess and re-transported loess (colluvium). The locally thick ice-rich inorganic and organic silt surface layer often contains minor sandy and gravelly layers at depth. Sediments in RSR overburden become coarser and thinner in vicinity of upslope exposed bedrock and grade in to MTV. Numerous shallow branching gullies commonly produce a horsetail drainage pattern. In tundra areas, dwarf willows and shrubs grow in and accentuate wet gully bottoms that impart a streaked character to the otherwise smooth-appearing landscape. In the transition northern forest belt (taiga), old burns are common. High ice contents are expected. Where surface waters have ponded in poorer-drained sites, they have caused local thawing; these areas are commonly mapped as FOL, SOL, SP (see below).

FOL Former oriented lakebeds in continuous permafront regions. Expect peat, silt, and fine sand in these small former lakebeds, many of them oriented and having linear shoreline portions. They are sites of former shallow, flat-bottommed, steep-sided lakes and are partly to entirely sediment-filled thaw basins. Outlines of the former thaw lakes are often barely discernible on high-level aerial photographs. Vegetation consists of wet tundra. Permafront table is located near ground surface. Anticipate high ice contents in the surficial silty zone with sand and gravel at depth on the North Slope, with clay, silt or sand at depth in areas of deep lacustrine (glacial-lake) sedimentation.

SOL Small oriented thaw lakes and ponds and intervening ground on the Arctic lower coastal plain. Oriented ponds frequently give the landscape a lineated appearance. Expect mainly thin (averaging about 5 feet) ice-rich silt over silty sand and gravel strata. Numerous wet ground and open-water crossings. Expect high ice content in the surface layer.

SP Speckled pattern of tiny ponds and patches of dark vegetation on undulating to rolling terrain. Often corresponds to poorly drained depressions in RSR terrain. Dark specks appear to be small ponds of standing dark (organic) water or patches of dark ground cover. Soils are expected to be mainly thin to thick inorganic and organic silt (loess?) over till, sand and gravel, and bedrock. IWP areas are commonplace. High ice contents are expected.

IWP Areas of ice-wedge polygons discernible on high-level (1 inch = 1 mile) airphotos. They commonly occur in poorly drained situations and in wet tundra on the Arctic lower coastal plain (areas of continuous permafrost). Paddy-like centers on raised-edge polygons are expected to consist of a thick mat of floating grass, sedges, mosses and roots, often in water a foot or two deep. The enclosing ice dykes may contaih longitudinal cracks filled with water. The dykes themselves are usually covered with grasses, sedges, mosses, lichens. Expect mainly surficial ice-rich organic silt and peat. Depressed-center polygons commonly occur on silty "fossil" (i.e., inactive) flood plains, old (former) silty lakebeds, and on flat to gently sloping lower coastal plain composed of surficial silty and fine sandy sediments. Expect very high ice contents.

ADDENDUM

GM Level to gently rolling ground moraine consisting mainly of compact "basal" till deposited subglacially. Texture of till reflects underlying bedrock types — i.e., clay-rich tills from clay shales, sandy tills from Precambrian Shield bedrocks and coarse sandstones, and silty tills from dirty fine-grained sandstones and siltstones (see bedrock-geology map). Land surface is commonly fluted — i.e., oriented subparallel grooves and ridges aligned in the direction of the last glacier flow. Cigar-shaped drumlinoid ridges occur in a few places and seem to be best expressed in areas mapped as GM/BR. The till is commonly overlain with silt, fine sand or clay up to 15 feet deep with depth to bedrock commonly ranging between 5 and 30 feet. The till should, on the average have appreciably lower water and ice contents than waterlaid and windlaid silt.

MAP SYMBOL

P Pingos. Mainly occur near the Arctic coast in gently sloping to old lakebottom areas underlain by thin (+ 5 feet?) ice-rich silt over silty sand and gravel strata. Peat and excessively high ice contents are expected.

BD Beaded (or buttonhole) drainage. Small "beads" of water (black dots) occur periodically along drainage courses, like beads on a cord. These beads are thought to be the result of permafront thaw at the intersection of tundra polygon sides. Expect high ice contents in surficial silt.

ETB Eroding thaw banks. Erosion has taken place in a variety of soil and rock materials. Frequently occur as compound slopes on steep valley banks, with the upper slope often appearing as a steep retreating scarp that may harbor snow for long periods each year. Locally, frost action and mass-wasting may take place beneath the snowbank.

AV Asymmetric valleys. Flatter slopes on exposed southeasterly-facing and south-facing sides of valleys and steeper slopes on north-facing and westerly-facing sides of valley walls. Usually occurs in continuous permafrost regions.

AFD Variable-textured granular alluvial-fan deposits. Mainly thin surficial silt and fine sand over sand and gravel in vicinity of fan periphery on the Arctic North Slope, with substrata grading to cobbles and even large boulders near the apex of larger alluvial fans.

ACD Alluvial cone deposits. Cone-shaped deposits composed of poorly-sorted "dirty" granular deposits ranging up to boulders in size. Located at the base of mountain slopes in the Brooks Range. Textural variations are often inferrable from the local geomorphic setting. These coarse deposits grade in to silty slopewash materials that contain high silt and ice contents in the Richardson Mountains.

TD Talus deposits. Bouldery to gravelly gravity-deposited materials in a silty matrix. Piles of talus commonly mantle middle to lower slopes in steep mountain terrain. Rockfall is a hazard.

SAS Steep avalanche-susceptible mountain sides. Includes remnants of former dirty snow and debris avalanches, avalanche chutes, and boulder tongues – all of which scar steep mountain sides. These deposits occur as piles at the base of steep slopes and as protalus ramparts.

OSF Old slide features. Includes undifferentiated rotational slumps and flow slides (mudflows composed mainly of clay and silt and liquefaction slides consisting mainly of stratified loose silt and fine sand). Failures occur mainly in overburden but this unit also includes some failures in soft bedrock, such as clay shales. Failures are common around the margins of upper valleysides in the foothill region west of the Peel River (on the east side of the Richardson Mountains), along the banks of the Mackenzie River and several of the deeper tributary river valleys that have downcut deeply in to lacustrine sediments (usually sand over silt and clay) -- i.e., lower Hume River, Mountain River, Great Bear River Valleys, among others.

OW Glacial outwash sand and gravel, minor silt. Includes outwash plains, outwash-delta deposits, valley-train terraces, fluvial terraces, and small isolated patches of outwash located at the downstream end of abandoned glacial meltwater channels. Usually well-drained and nearly level in thawed areas. Relatively low segregated ice contents; but this varies with latitude and mean annual temperature. Large tundra polygons are common on outwash in the "barrens" region (continuous permafrost region). Potential source of sand and gravel and fill material where unfrozen. Outwash terrace and delta deposits above the banks of large rivers tend to be high in sand sizes, and to have a peat and silt surface layer that is usually less than 5 feet and rarely over 15 feet in thickness.

AMX Alpine moraine complex. Coarse bouldery moraines resulting from multiple valley glaciations in the Brooks Range. Mainly a complex map-unit consisting of thin bouldery glacial moraine and glacier-eroded rock outcrops on lower mountain slopes in narrow mountain valleys and foothill regions of the Brooks Range. Locally the moraine complex contains sand and gravel kames and enclosed pockets of stratified silt, sand, gravel, and boulders in the till. Talus and slopewash debris frequently mantle and mask the upper limits of AMX -- i.e., below glacially oversteepened, unvegetated mountain slopes in the continuous permafrost zone.

MTV Mountain valley pediments. Smoothly rounded, streaked upper valley sides in mountainous, submountainous, low intermontane and foothill regions. Grades into "felsenmeere" in vicinity of upslope bedrock outcrops. Slopes appear to be old (Tertiary?) pediment surfaces next to bedrock mountain slopes. But even here the bedrock may be overlain by a mantle of interlayering alluvium, colluvium, or eolian materials. Expect organic silt (loess and colluvium?) that is ice-rich and probably becomes thicker downslope, but rarely exceeds 50 feet in thickness. Located in tundra areas underlain by continuous permafrost. Rillwash drainages are parallel to subparallel and tend to coalesce and branch. Grades in to RSR downslope and BR upslope.

LST Solifluction sheets and lobes. Silty gravel to boulders on steep valley sides. Near-surface layer may be actively creeping -- i.e., moving downslope a few centimeters a year. On steep slopes these features usually indicate a thin silty layer over bedrock; on more gentle slopes, they commonly reveal a shallow permafrost table. They are characteristic of continuous permafrost regions.

BR Extensive bedrock outcrops on rugged mountain slopes and thin soils over bedrock on subdued and subrounded slopes in foothills regions. Lower BR slopes may change abruptly or transitionally to MTV. The bedrock is often covered with angular bouldery felsenmeere (block fields) that appears to follow fracture planes in the bedrock where frost action and rock splitting has been an active process.

MAP SYMBOL

GLB Glacial lake-bed plains. Mainly ice-rich thick (over 50 feet) glacial-lake deposits composed of silt with some fine sand, clayey silt and clay strata locally. Large flow slides have occurred along steep valley walls cut in deep sections of these sediments. Although areas of TK terrain are commonplace in GLB, thaw lakes are not widespread enough to be classed as "TK", which is a somewhat arbitrary distinction and separation. Lakebed silt tends to become thinner and to feather out along the margins of former proglacial lakes that occupied the Peel and Mackenzie Plains. Peat up to 10 feet deep is common in poorly drained basins.

TK Extensive thermokarst topography developed in widespread poorly drained, thick (commonly 3 to 12 feet) peaty tracts that are nearly flat or depressional and are underlain mainly by waterlaid fine-grained soils (GLB and FFP) with or without a thin surficial sand cover. Heat from water in thaw pits, sinks, and ponds results in melting of ground ice in areas of saturated peat and underlying mineral soils. The thaw basins may enlarge to the point of coalescing. The thaw basins are usually steep-sided and flat-bottommed and are best developed in peat-covered stratified waterlaid silt and fine sand.

RB Raised beach ridges, spits, and strandlines. Contour-like small ridges of mainly sand and gravel and small wave-cut notches at successive levels around former glacial-lake basins. These features are usually discontinuous, having been either eroded or buried by loessial and slopewash silt.

DIM Knobby dead-ice moraine composed largely of superglacial (ablation) till layer buried beneath a variable thickness of ice-rich silt (water – or wind-laid). The knob-and-kettle topography results in poor drainage and high ice contents in the surface silt. The till layer includes kames and probably overlies stratified silt and clay locally. This unit is very complex in detail.

ET Gently to strongly sloping gully-scarred till plain, with or without a thin surficial silt layer. Erosion consists mainly of surface-runoff gullying and sheet erosion but also includes minor wave erosion. In the absence of rock outcrops, the depth from ground surface to bedrock is difficult to predict from the photos but probably the drift thickness falls in the 2- to 20-foot range. Likewise, the surficial ice-rich silt layer probably varies from 0 to 15 feet.

CAF Coalescing alluvial-fan and slopewash deposits. Below the Richardson Mountains in the region west of Aklavik, these deposits are expected to be mainly ice-rich pebbly organic silt and fine sand derived from weathered siltstones, sandstones, and shales in contributing watersheds in the adjoining Richardson Mountains. Active stream channels and sediment-buried distributaries carry higher proportion of gravel sizes. Typically the area is wet, has a high permafrost table, and is subject to flooding. In the valleys of the Richardson Mountains in the eastern Yukon, the coalescing silt fans often contain large masses of pure ice and minor sandy and gravelly layers.

MRD Mackenzie River delta terrain. Maze of sinuous abandoned and active interlacing channels separated by wooded natural levees, numerous thaw lakes, ponds and sloughs, many of them partly filled with deep peat and fine-grained sediments. Peat is common in poorly drained areas. Ground ice has completely melted below some of the deeper and larger thaw lakes. Elsewhere the permafrost table is expected to be only a few feet below ground surface.

E Eskers. Usually small, sinuous, locally branching, discontinuous (i.e., segmented) ridges. Complexly stratified silt, sand, and gravel with minor inclusions of till. Variable composition. Potential source of road-building fill and surfacing materials. Expect volume of usable granular material to be small and composition to be quite variable.

K Kames. Irregular-shaped mounds of complexly stratified poorly sorted silt, sand, and gravel of ice-contact origin. Includes kame-terraces and kame-deltas. Kames are possible if poor sources of fill borrow and road-surfacing granular materials.

PAL Palsa-bog terrain. Conspicuous palsas are domelike mounds that can be 10 feet or more high. They often contain complexly interlayered peat, silt, fine sand, and ground ice. In the discontinuous permafrost zone, black-spruce "islands" are often former palsa mounds; they are sometimes called "frost mounds," "peat mounds," and "peat plateaus." Palsas are usually intermingled with sedge meadows and shallow open water in near-circular thaw ponds, pits, and sinks (thermokarst). Usually occurs in low-lying poorly drained depressions underlain by waterlaid ice-rich silt over till. Peat may reach 30 feet thickness in hummocky dead-ice moraine areas in the southern permafrost fringe.

MK Muskeg and swamp. Large areas of moderately deep to deep (averaging over 5 feet in thickness) wet, peaty terrain. Occurs in poorly drained depressions. In the southern fringes of permafrost areas, the ground ice has likely melted and disappeared below saturated peat areas (sedge meadows) whereas it may still be preserved in elevated drier peat areas that have been shaded by spruces and insulated by a thick Sphagnum moss cover.

SB String bog. Also called "ridge-and-pool bogs," "ribbed fen," and "patterned fen." "Strings" trend normal to runoff direction and are usually vegetated by black spruce, tamarack, dwarf birch, alder, and sedge. Intervening depressions may contain water, bare soil, or be covered by lichens, mosses, and heath. These peatlands are fed by slowly downslope-migrating surface and ground waters.

WT Whitish-toned patchlike areas of peatland locally mainly on the Peel Plain. Suspect invasion of reindeer lichen, Sphagnum moss, and sedges following succession of old forest-fire burns. Large patches of grey lichen occur in flat areas to slight depressions in areas of alleged thin drift (mainly thin silt and/or till) over shale. Expect ground-ice in peat and in surficial mineral soils. Expect variable peat depth but commonly ranging from 5 to 12 feet. Small thermokarst features are usually present in the landscape.

L Lakes. Mainly oriented large thaw lakes. The shorelines on these shallow lakes have been modified by wind, wave, and current action in continuous permafrost regions and tend to show systematic orientations. Includes also other lakes in the discontinuous permafrost zone.

Drumlinized and/or fluted till. Includes patches of thin silt over till over bedrock, and/or fluted bedrock at ground surface. This symbol is shown because these ridges are thought to represent better pipeline locations. Their long axes match the direction of the last glacier advance.

NOTES ÷

1. Map-units shown in the legend are based mainly upon airphoto-interpreted landforms and depositional environments considered to give rise to a characteristic stratigraphy and range of overburden soil materials and a typical range of topographic, drainage, and permafrost conditions.
2. The term "ice-rich" suggests that most of the testholes are likely to encounter segregated ice ranging from 15% to 50% by volume.
3. Depth of surficial peat is expected to be substantially thinner in the continuous permafrost zone than it is in the discontinuous permafrost zone, with a general increase in peat depth in a southward direction.
4. The terms "thin" and "thick" are used in a relative sense. If, for example, a surficial silt layer over a sand and gravel or till stratum averages 7 feet or less in thickness, with a common maximum depth of 15 feet, the surficial silt layer is considered "thin". On the other hand, if the total overburden thickness (say, peat plus ice-rich silt plus till) over bedrock averages less than 20 feet, with a common maximum depth of 30 feet, the total overburden over bedrock may be referred to as "thin". And any surficial peat layer over 5 feet is likely to be referred to as "deep" or "thick".

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT
MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

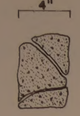
PROJECT
MACKENZIE VALLEY PIPELINE

TITLE
J. D. Mollard and Associates Limited
Description of Map Symbols

SUBMITTED	DATE	SITE No.	PLATE No.
J. D. Mollard	Dec/70	–	3
APPROVED	DATE	SHEET No.	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE.



Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

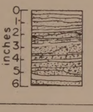
Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK.

Vx INDIVIDUAL ICE INCLUSIONS

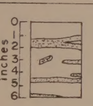
Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS



Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL – ICE –

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
ACP	Arctic lower coastal plain; mainly thin silt over silty to clean sand and gravel
AFP	Active flood plain; mainly exposed sand, gravel and cobbles with boulders locally
BD	Beaded drainage
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel
FOL	Filled former oriented lakes; mainly thin ice-rich peat and organic silt over sand and gravel or till
IWP	Ice-wedge polygons; mainly developed in ice-rich silty deposits
L	Lakes; mainly large oriented thaw lakes
P	Pingos; mainly thin ice-rich silt over silty sand and gravel
SOL	Small oriented thaw lakes; mainly thin ice-rich silt over till or sand and gravel

SEE PLATE No 3 for a comprehensive description of symbols.

MILE 0

Eroding thaw banks

1 A_o B_o C_o Active flood plain (AFP) with very sparse vegetation, grasses and low crawling broad leaf shrubs. Picture 1 is an aerial view of the area. Ground consists mainly of clean, well-graded sand and gravel (quartzite, limestone, shales and cherts) up to 2" max. size. Silt and sand overlies gravel in low-lying areas. (Pictures 2 and 3) Depth to frozen gravel is about 3' on the flood plain, and presumably greater in the stream beds.

Gravel is used for road and pad construction in the area. Close-up of a gravel stockpile is shown on Pictures 4 and 5.

Pingo-like mound with sedge cover, Picture 6, located on a "fossil" flood plain about ½ mile from Site 1 A B C. Near surface soil is silty sand. On the side slope, soil is frozen below 9½' and at the top and at the base, soil is frozen 2½'.

1 D_o On an extensive "fossil" flood plain, (FFP) near a gravelly meander. Within a radius of 100' there are three different surface features:

- slightly depressed sedgy area with sparse growth; about 2" of organic cover over 1½' of clayey silt overlying sand and gravel. Ground unfrozen to 2½' at least (probe stopped either by rocks or by frozen ground).
- "crazed" crack pattern, 5' to 10' across. Three-inch moss over 3" of silt over sand and gravel.
- polygonal mounds 2' in diam. and 4" in height; composed of sandy silt with no evidence of ice lensing. Frozen below 18".

Ragged eroding shore line.

Straight and regular shore line.

Typical SOL terrain as shown by Picture 7; note pingo in background.

IWP pattern made distinct by water lying along edges of polygons.

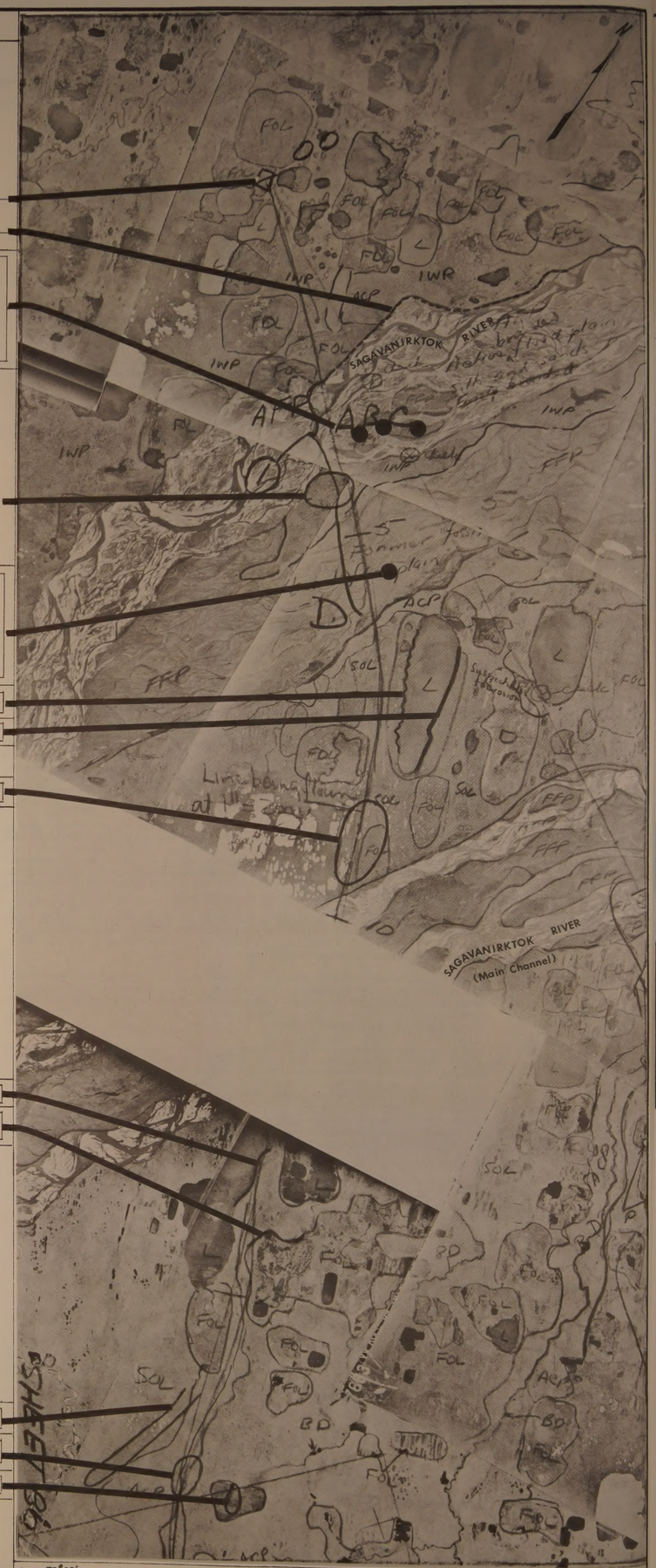
Beaded drainage in IWP ground, very small ponds.

Banks of former old lake, 5' high; appear to be higher than similar lakes in this area.

Old drainage channel, infilling.

Infilling SOL in IWP ground.

Lake starting to infill with sedge.



LAT 70°10'
LONG 148°10'

AVE. ALTITUDE 50'
MEAN ANNUAL AIR TEMP. 9° F

SITE NO. 1 SHEET NO. 86
PLATE NO. 4

Picture: 1 Aerial view of Sagavanirktok River flood plain at site location
Site: 1 $A_oB_oC_o$

Picture: 2 General view of the active flood plain
Site: 1 $A_oB_oC_o$

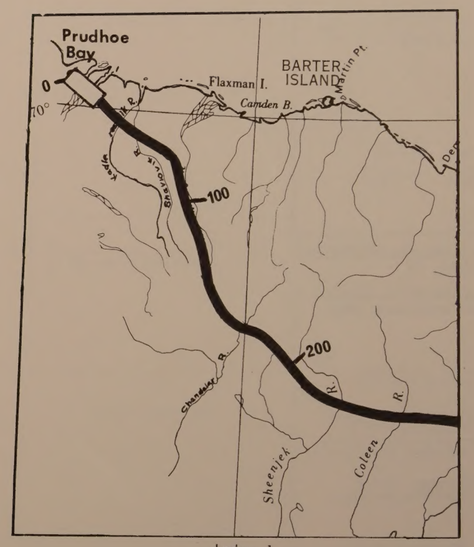
Picture: 3 Cross-section of a bank: silty cover overlies sand and gravel
Site: 1 $A_oB_oC_o$

Picture: 4 Stockpile of gravel excavation from the river
Site: 1 $A_oB_oC_o$

Picture: 5 Close up picture of the gravel stockpile
Site: 1 $A_oB_oC_o$

Picture: 6 The pingo-like mound on an isolated inactive flood plain
Site: ½m. from 1 $A_oB_oC_o$

Picture: 7 Aerial view of a typical SOL and lake terrain, pingo in background
Site: 1



Index 1

Pictures taken in late August, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE
	TITLE: Photo Mosaic and Terrain Investigation MILE 0 TO MILE 18
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: R Jewell DATE: Dec/70 SITE No.: 1 PLATE No.: 5
	APPROVED: Curlpeen DATE: Dec/70 SHEET No.: 86

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
SEGREGATED ICE NOT VISIBLE BY EYE				
Nf POORLY BONDED	2 A_T	Moss with grass tufts 8" to 12" diam.	0 - 1' ORGANIC, moss, frozen below 8" 1' - 2' ICE 2' - 10' SILT, peat & segregated ice (Vr) 10' - 21' SAND & GRAVEL (Nbe, Nbn)	2 A_T Center of mound (ACP) General surface is grass tufts 8" to 12" diam. within slightly raised mounds. Upper 12" is moss and peat.
Ndn WELL BONDED — NO EXCESS ICE	2 B_T	Mosses, grasses & peat. Raised edge of polygon, 6" to 2' above center area.	0 - 14" ORGANIC, peat to 6", organic silt to 14", frozen below 14" 14" - 14' ICE 14' - 19' GRAVEL & SAND becoming coarser at 18'	2 B_T In raised edge of polygon (IWP)
Nbe WELL BONDED — EXCESS ICE	2 C_T	Mosses, grass & peat. Swampy with free standing water.	0 - 15" ORGANIC peat, frozen below 15" 15" - 10' SILT, ice inclusions (Vr) 10' - 17' SAND fine, (Nbn) 17' - 20' GRAVEL, sandy (Vc, Vr)	2 C_T In center of polygon (IWP)
VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK				
Vx INDIVIDUAL ICE INCLUSIONS	2 H_T	Mosses, grass, lichens. Hummocks 1' to 2' in height and 6" to 10" diam.	0 - 7" ORGANIC, peat 7" - 7' SILT, organic, frozen below 12", ice lenses and inclusions (Vr, Vx) 7' - 15' SAND, fine, silty (Nbn) 15' - 20' SILT, (Nbn)	2 H_T Edge of small partially open pond. General surface is very hummocky; hummocks are 1' to 2' high and 6" to 10" in diameter. Growth also of lichen and small shrubs. Small pond (see sketch) is infilling on easterly side. See Pictures 1, 2, 3, 4. Height of bank is about 2'; no colapsing apparent. Lake bottom comprised of finely-divided peat; & looks like coarse sand.
Vc ICE COATINGS ON PARTICLES	2 I_T	2" water on a slurry of coarsely divided peat ("porridge-like")	Probing at edge of pond - 16" to frozen ground at center of pond- 18" to frozen ground	2 I_T Probing in small pond; see Picture 5
Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS				
Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS				
VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK				
ICE & SOIL ICE WITH SOIL INCLUSIONS	2 D_T	Mosses, grass & lichen.	0 - 14" ORGANIC, moss and grass, frozen below 14" 14" - 5' SILT, ice lenses and inclusions (Vr, Vx) 5' - 13½' SAND, silty, ice crystals (Vx) 13½' - 20' GRAVEL & SAND, (Nbn)	2 D_T At edge of lake. Grasses, lichens & mosses in polygonal ground. Frozen at 1' in trough and 1½' in center of polygon. Unfrozen material is peat. Banks of lake north & west collapsing. Banks are about 18" in height.
ICE ICE WITHOUT SOIL INCLUSIONS	2 E_T	Clear water up to 6 feet deep	Probing at lake shore - water depth = 10"; frozen at 17" below lake bottom. 200' from shore - water depth = 6'; granular bottom could only probe to a depth of 2' below lake bottom but appeared frozen 700' from shore - water depth = 6'; granular bottom unable to determine if frozen or unfrozen with probe.	2 E_T Probing in middle of lake.
LEGEND: SOIL - ICE -				
	2 F_T	Mosses, grass & lichens in small mounds and exposed gravel.	0 - 3" ORGANIC, moss 3" - 3' SAND, silty, frozen below 12" (Vx) 3' - 7' ICE with silt inclusions 7' - 28' SAND, silty, ice lenses and inclusions (Vr, Vx)	2 F_T Top of pingo near perimeter. General area is exposed gravel (includes shale, sandstone, granite), Picture 6, and small mounds of moss, grass and lichens covering gravel toward center of pinto. Depression at easterly portion of pingo, Picture 7, is grass covered. Area of pingo at top is about 200' x 800' max; height 44'.
	2 G_T	Moss & grass tufts.	0 - 4" ORGANIC, moss 4" - 6' SILT, organic, frozen at 12" ice lenses and inclusions (Vr, Vx) 6' - 12' SAND, silty ice lenses and inclusions (Vr, Vx) 12' - 15' ICE, sand inclusions 15' - 20' SILT, sandy ice lenses and inclusions (Vr, Vx) 20' - 30' SAND, fine to medium (Nbn)	2 G_T On gentle slope at base of pingo about 5' above plain
				2 J_O On lake of pingo Surface is dry and grass covered, see Pictures 8 & 9. The side slope of the pingo is covered with moss and lichen, with a few buttercup flowers, see Picture 10. Mounds in vicinity of pingo on the west side, see Picture 11.
				2 K_O Pingo with water around base. Note eroded steep banks, Picture 12; and collapsing banks with gravel at water's edge, Picture 13.

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
ACP	Arctic lower coastal plain; mainly thin silt over silty to clean sand and gravel
AFD	Variable-textured alluvial fans; mainly thin silt over sand and gravel with major textural variations often inferrable from local geomorphic (depositional) setting
AFP	Active flood plain; mainly exposed sand, gravel and cobbles with boulders locally
BD	Beaded drainage
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel
FOL	Filled former oriented lakes; mainly thin ice-rich peat and organic silt over sand and gravel or till
IWP	Ice-wedge polygons; mainly developed in ice-rich silty deposits
L	Lakes; mainly large oriented thaw lakes
P	Pingos; mainly thin ice-rich silts over silty sand and gravel

SEE PLATE No 3 for a comprehensive description of symbols.

LAT. 70°
LONG. 147° 55'
AVE. ALTITUDE 50'
MEAN ANNUAL AIR TEMP. 9° F

SITE NO. 2 SHEET NO. 86 A
PLATE NO. 6

Picture: 1 Small ingrown pond.

Site 2 H_T, I_T

Picture: 2 Infilled pond.

Site 2 H_T, I_T

Picture: 3 Close-up of vegetation around lake.

Site 2 H_T, I_T

Picture: 4 Pond infilling from easterly site.

Site 2 H_T, I_T

Picture: 5 Probing in small pond.

Site 2 I_T

Picture: 6 Top of pingo shows gravelly surface. Rocks are granites, shales and sandstone.

Site 2 F_T

Picture: 7 View of depression at top of pingo showing grass growth.

Site 2 F_T

Picture: 8 Dry grass covered surface between lake and pingo.

Site 2 J_0

Picture: 9 Vegetation at bottom of pingo, grass dry.

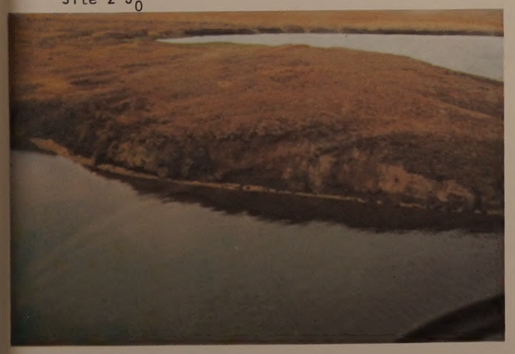
Site 2 J_0

Picture: 10 Vegetation on side slope of pingo.

Site 2 J_0

Picture: 11 High center polygons on west side of pingo.

Site 2 J_0

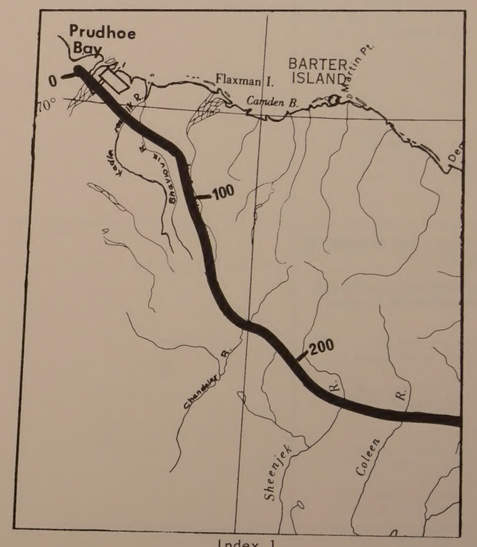


Picture: 12 Eroded banks of pingo at water's edge, southerly side.

Site 2 K_0

Picture: 13 Collapsing banks of pingo at water's edge, northerly side.

Site 2 K_0



Index 1

Pictures taken in late August, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 5 TO MILE 18 Offset

SUBMITTED	DATE	SITE No.	PLATE No.
R Jewell	Dec/70	2	7
APPROVED	DATE	SHEET No.	
Furgeson	Dec/70	86A	

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Ndn WELL BONDED — NO EXCESS ICE

Nde WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ICE-

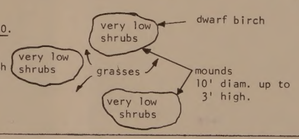
AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

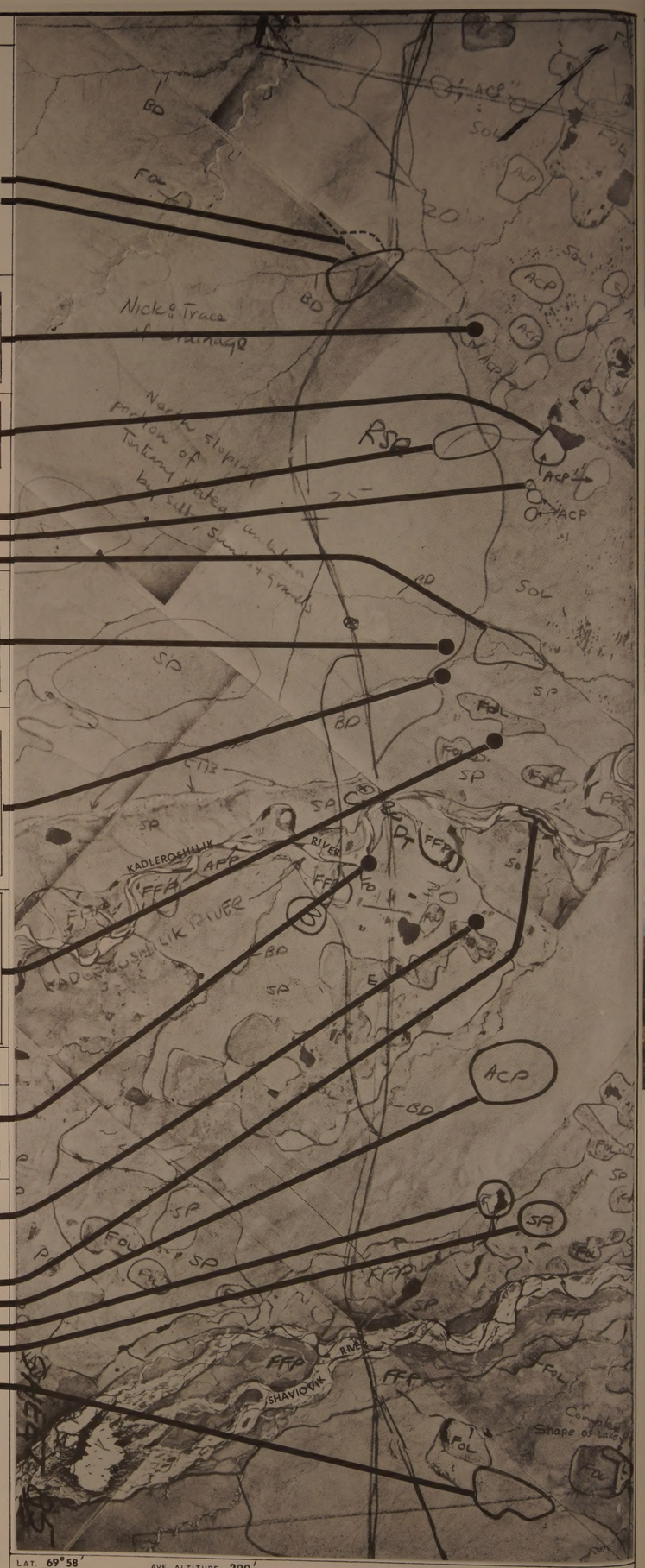
J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
ACP	Arctic lower coastal plain; mainly thin silt over silty to clean sand and gravel
AFP	Active flood plain; mainly exposed sand, gravel and cobbles with boulders locally
BD	Beaded drainage
ETB	Steep, eroding thaw banks; includes banks containing silt, sand, gravel, till or bedrock
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel
FOL	Filled former oriented lakes; mainly thin ice-rich peat and organic silt over sand and gravel or till
L	Lakes; mainly large oriented thaw lakes
P	Pingos; mainly thin ice-rich silt over silty sand and gravel
RSR	Smoothly rolling silt-mantled sand and gravel, till, or bedrock plains; mainly redeposited loess consisting of thin to thick ice-rich organic silt with occasional organic bands
SOL	Small oriented thaw lakes; mainly thin ice-rich silt over till or sand and gravel
SP	Speckled pattern of small ponds on undulating to rolling plain; mainly thin to thick ice-rich loessial silt over till or bedrock or sand and gravel

SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
			Infilled beaded drainage. Ice-wedge polygon terrain starting to form in vicinity
			Beaded drainage and small ponds in beaded pattern. Also IWP along channel.
3 G_T	Moss, grass tufts and small hummocks; surface relatively smooth overall.	0 - 4" ORGANIC, moss and grass 4" - 1½' ORGANIC, silty frozen below 16" 1½' - 3½' SAND, gravelly (Nbn) 3½' - 19' GRAVEL, sandy, ice inclusions (Vr)	3 G_T On top of ACP terrain ACP terrain is slightly raised ground covered with small hummocks of grass
			3^H_0 ACP terrain is generally smooth. See Picture 1. Thin organic cover overlies a silt and gravel mixture. See Picture 2.
			Ice-wedge polygon along beaded drainage
			Area appears to be raised with pronounced ice-wedge polygons
			Beads of drainage nearly all connected
3 A_T	Moss and grass tussocks with sparse dwarf shrubs. See Pictures 3 & 4.	0 - 2" ORGANIC moss 2" - 3' SILT, organic, frozen below 18" 3' - 9' ICE, silt lenses 9' - 14' SAND, very silty (Vr, Vx) 14' - 21' ICE, silt inclusions 21' - 30' SILT, ice lenses & inclusions 30' - 33' GRAVEL, frozen	3 A_T On gentle slope of RSR terrain. RSR terrain, small tussocks of moss & grass. See Picture 3 and 4.
			3 B_0 Beaded drainage, water is 5' to 10' deep and appears brown in color. Banks 6' high some slumping occuring at isolated points. See Picture 5. Beads both in-filling and enlarging and beads generally have steep V-shaped channels. See Picture 6. Picture 7 shows gravel and peat in bottom of bead.
3 D_T		Probing at pond edge - 2" water over 18" of finely divided peat slurry frozen at 18" - 3' from edge, 18" of water over 6" of peat slurry, frozen at 2' - center, 3' of water and then on ice	3 C_T & 3 D_T SP terrain. See Picture 8, 9 & 10.
3 C_T	Moss, grass & lichen cover with mounds up to 3' in height.	0 - 10" ORGANIC, moss, peat, frozen below 10" 10" - 11' SILT, highly organic, ice lenses 11' - 20' GRAVEL & SAND, ice crystals (Vx)	3 C_T 6' from edge of pond. Mounds with dwarf shrubs with reddish narrow leaves. See Picture 10.
			3 F_0 River banks approx. 20' high; slope approx. 1:1; no apparent under-cutting; top of bank deteriorating slowly. Bank exposure 8' of silt and fine sand over gravel. See Picture 11. Active flood plain shows well-graded sand and gravel with cobbles to 6". See Picture 12.
			3 E_0 FOL; banks 2'-2½' high.
			Gravel banks show slight deterioration at top.
			ACP with faint IWP patterned ground.
			Lake infilling from west bank.
			Small ponds and raised polygonal mounds with reddish-colored vegetation; same as shown in Picture 10.
			Prominant polygons with depressed centers.





LAT. 69°58'
LONG. 147°50'

AVE. ALTITUDE 200'
MEAN ANNUAL AIR TEMP. 9°F

SITE NO. 3 SHEET NO. 85
PLATE NO. 8

Picture: 1 View of overall smooth ACP terrain

Site: 3^{H}_{0}

Picture: 2 View of silt gravel mixtures

Site: 3^{H}_{0}

Picture: 3 Close-up of surface cover test hole on RSR terrain

Site: 3^{A}_{T}

Picture: 4 Close-up of vegetation on RSR terrain

Site: 3^{A}_{T}

Picture: 5 Shows slumping at bead

Site: 3^{B}_{0}

Picture: 6 Shows bead. Water level in beads are at different elevations due to incomplete connections between ponds

Site: 3^{B}_{0}

Picture: 7 Shows gravel & peat in bottom of bead. Photo taken from 6' through the water.

Site: 3 B_{o}

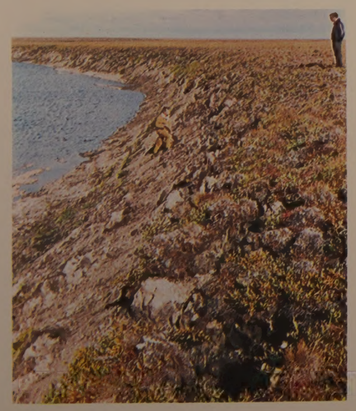
Picture: 8 Small pond, general view

Site: 3 C_T & D_T

Picture: 9 Close-up of vegetation on SP terrain

Site: 3 C_T & D_T

Picture: 10 Shows, speckled terrain with mounds up to 3' in height. These mounds might give the appearance of SP terrain

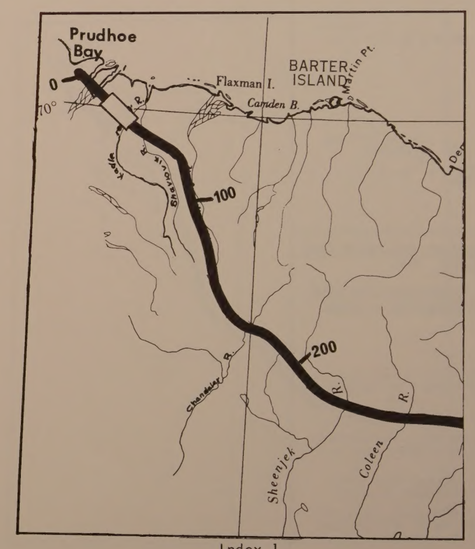


Picture: 11 Shows bank of Kadleroshilik River

Site: 3^{F}_{0}

Picture: 12 Shows gravels on flood plain

Site: 3^{F}_{0}



Index 1

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 16 TO MILE 38

SUBMITTED	DATE	SITE No.	PLATE No.
Jewell	Dec/70	3	9
APPROVED	DATE	SHEET No.	
Ewbeer	Dec/70	85	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

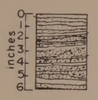
Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS



Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
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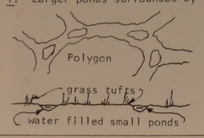
FOL	Filled former oriented lakes; mainly thin ice-rich peat and organic silt over sand and gravel or till
IWP	Ice-wedge polygons; mainly developed in ice-rich silty deposits
L	Lakes: mainly large oriented thaw lakes
RSR	Smoothly rolling silt-mantled sand and gravel, till, or bedrock plains; mainly redeposited loess consisting of thin to thick ice-rich organic silt with occasional organic bands
SP	Speckled pattern of small ponds on undulating to rolling plain; mainly thin to thick ice-rich loessial silt over till or bedrock or sand and gravel

SEE PLATE No 3 for a comprehensive description of symbols.

Pingo

Lake is infilling on south and west sides, bank eroding on north and east sides encroaching on the adjacent IWP terrain.

Aerial view of this terrain is shown on Picture 1. Larger ponds surrounded by sedges are visible from the air (for close-up, see picture 2.) The terrain appears to be a faintly defined IWP with numerous small ponds (BD) forming at the intersections of polygons as shown by the opposite sketch. The vegetation is small grass tufts as shown on Picture 3. One of the small mud boils found in this area is shown on Picture 4.



Erosion of unnamed creek bank

Seismic line eroded to approx. 2' depth along distance shown.

Many ponds and mounds of reddish vegetation.

Lakes are infilling on west side, bank erosion on east side.

Pictures 5 and 6 show the aerial view of this terrain speckled predominantly by reddish vegetation (see close-up Pictures 7 and 8.) Ponds about 8' in diameter, are concealed by ingrowing sedges as shown on Picture 9.

Small ponds of water and tufts of grass

Beaded drainage (BD)

Area of IWP

Appears to be a drainage ditch.

Camp and airstrip at Kavik River

Aufeis along the river bank

Lake is infilling from west

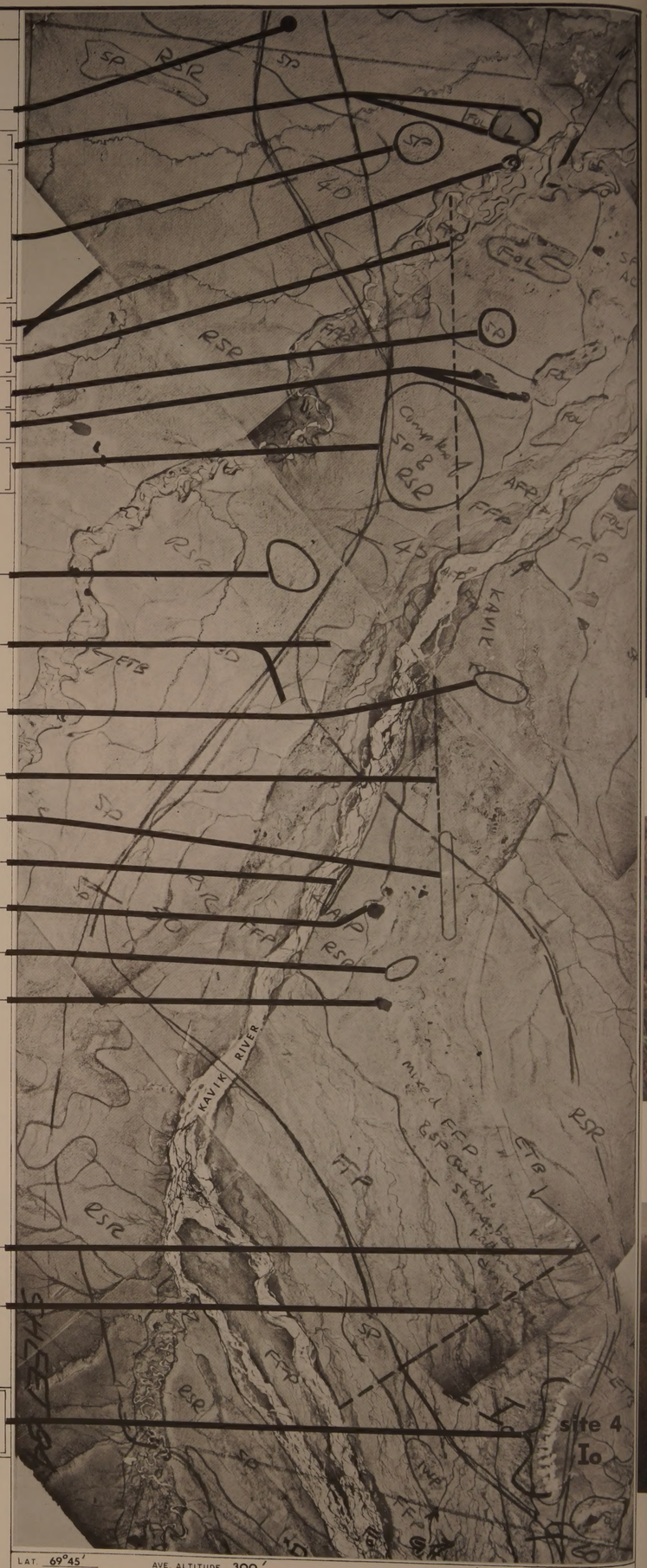
Speckled terrain (see Picture 10)

Lake is infilling from west

Slope erosion at the top of bluff (Picture 11)

Seismic line eroding

$4\,I_o$ The white reflection is a line of bluffs as shown by Picture 12. A mixture of sand and gravel with silt binder is exposed over these bluffs. Rock types include cherts, quartzite, and quartz and some sandstone, Picture 13. The vegetation growth is sparse as shown on Picture 14. There is no evidence of bedrock.



LAT. 69°45'
LONG. 147°15'

AVE. ALTITUDE 300'
MEAN ANNUAL AIR TEMP. 10°F

SITE NO between 3 & 4 SHEET NO. 84
PLATE NO. 10

Picture: 1 Aerial view of SP terrain with visible ponds
Site: between 3 & 4

Picture: 2 Pond surrounded by sedges (measuring tape in foreground)
Site: between 3 & 4

Picture: 3 Grass tufts with dwarf willow
Site: between 3 & 4

Picture: 4 Frost or mud boil
Site: between 3 & 4

Picture: 5 Aerial view of SP terrain with speckles of reddish vegetation.
Site: between 3 & 4

Picture: 6 Aerial view of SP terrain, (visible pond in center).
Site: between 3 & 4

Picture: 7 Dwarf willow and birch shrubs among grass tufts.
Site: between 3 & 4

Picture: 8 Dwarf willow and birch shrubs
Site: between 3 & 4

Picture: 9 One of the ponds, 8' in diameter, concealed by ingrowing sedges.
Site: between 3 & 4

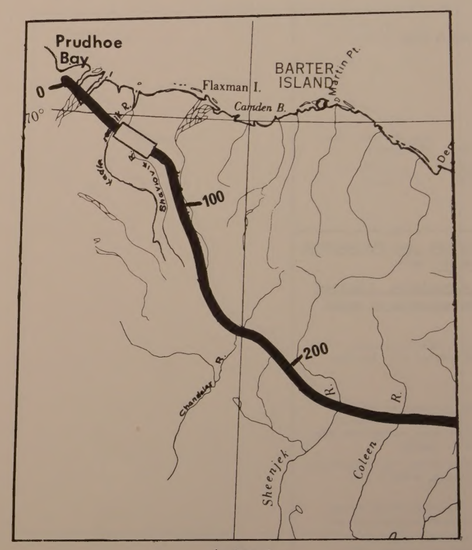
Picture: 10 Aerial view adjacent to lake with reddish speckled appearance in IWP terrain
Site: between 3 & 4

Picture: 11 Slope erosion at top of bluff. Water following old siesmic line leading to erosion trench.
Site: 4 I$_0$

Picture: 12 Aerial view of bluffs along Kavik River
Site: 4 I$_0$

Picture: 13 Close up picture of gravel at top of bluff
Site: 4 I$_0$

Picture: 14 Sparse vegetation on top of bluff
Site: 4 I$_0$



Index 1

Pictures taken in late August, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 36 TO MILE 60

SUBMITTED	DATE	SITE No.	PLATE No.
R Jewell	Dec/70	between 3+4	11
APPROVED	DATE	SHEET No.	
Eve Speer	Dec/70	84	

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

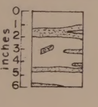
Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSION

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ICE-

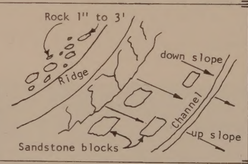
AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
AFP	Active flood plain; mainly exposed sand, gravel and cobbles with boulders locally
AV	Asymmetric valleys
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and sub-rounded in foothill regions
ETB	Steep, eroding thaw banks; includes banks containing silt, sand, gravel, till or bedrock
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel
FOL	Filled former oriented lakes; mainly thin ice-rich peat and organic silt over sand and gravel or till
IWP	Ice-wedge polygons; mainly developed in ice-rich silty deposits
OW	Glacial outwash; mainly sand and gravel with minor silt, often with thin silt mantle
RSR	Smoothly rolling silt-mantled sand and gravel, till, or bedrock plains; mainly redeposited loess consisting of thin to thick ice-rich organic silt with occasional organic bands
SP	Speckled pattern of small ponds on undulating to rolling plain; mainly thin to thick ice-rich loessial silt over till or bedrock or sand and gravel

SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
4 G_T	Moss and grass; free water in grass	0 - 1' ORGANIC, moss, peat frozen below 12" 1' - 7' ICE, peat and silt inclusions 7' - 13' GRAVEL & SAND, (Nbn)	4 G_T Depressed center of polygon with moss and grass growth. Free standing water in depression.
4 H_T	Moss, grass and hummocks	0 - 13" ORGANIC, moss, silt, frozen below 13" 13" - 2' SILT, ice inclusions (Vr) 2' - 4½' ICE 4½' - 15' GRAVEL & SAND, possible ice.	4 H_T At raised edge of polygon. IWP terrain with raised edge polygons; ridges about 12" above center of polygons (see Picture 1) The ground is hummocky with moss and grass vegetation as shown on Picture 2.
4 B_T	Moss and grass on hummocky surface, few dwarf shrubs.	0 - 2½' ORGANIC, silt and peat, frozen below 12" 2½' -14' ICE 14'- 47' SILT, ice inclusions (Vr) (Vx) 47'- 49' GRAVEL & SAND	4 B_T In hummocky area.
4 C_T	On flat area. Vegetation is moss and grass.	0 - 2' ORGANIC, moss, silt and peat, frozen below 12" 2' - 5' ICE 5' - 9' SILT, organic, ice inclusions (Vr) 9' - 20' ICE, silt inclusions	4 C_T Adjacent to pond. Flat SP area, close to a small pond as shown on Picture 3. The ground surface is grassy with some moss, grass hummocks and a few dwarf shrubs, Picture 4.
4 D_T	Large moss and grass tufts up to 2' in diameter. Level and dry ground.	0 - 12" ORGANIC, peat and silt, frozen below 12" 12"- 2' SILT, ice inclusions (Vr) 2' - 13' ICE 13'- 45' SILT, ice inclusions (Vr) 45'-48' GRAVEL & SAND	4 D_T On flat RSR terrain. General surface is flat to gently sloping, hummocky ground with large grass tufts. See Picture 5.
			4 F_0 Active flood plain (AFP) at Kavik River. Well-graded gravel and sand; max. size up to 8". The gravel contains intrusive and sedimentary rock pebbles and is coarser than the AFP deposits farther downstream, see Picture 6.
4 E_T	4" moss with lichen and scattered dwarf shrubs.	0 - 2' GRAVEL & SAND, silty, cobbles at 2'.	4 E_T FFP terrain is covered with lichen over 4" of moss. Scattered dwarf bushes and grass vegetation, see Picture 7.
			4 A_0 Top of mesa; see Picture 8. Porous sandstone bedrock; extensively fractured by ice wedging and weathering. Boulders up to 20' across strewn down slope. Nearby seismic line deteriorated to about 4'.



Camp and airstrip, gravel exposed in cuts along runway.

4 L_0 Vertical bituminous coal seam about 6" thick in fractured sandstone exposure.

Sandstone ridge

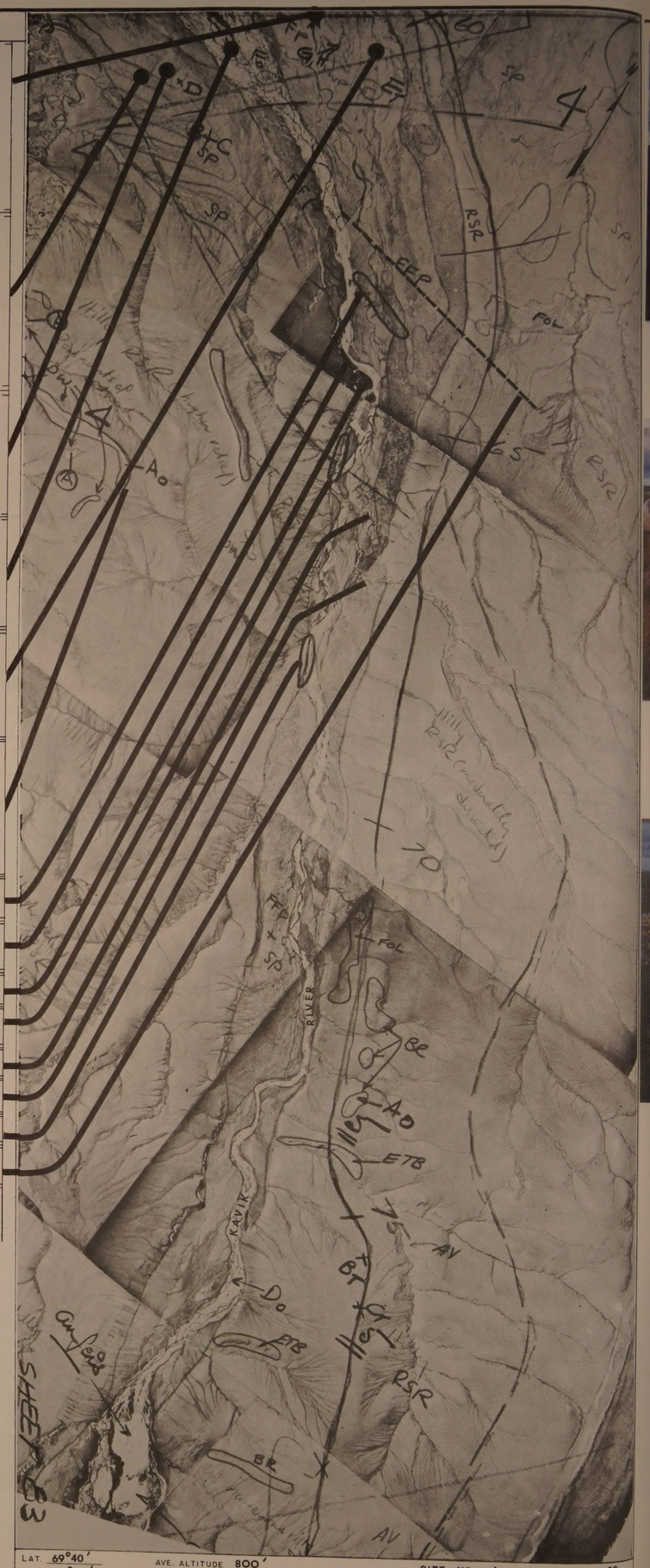
4 M_0 Bank is soft wet fractured "claystone," overlain by gravel (see Picture 9)

Drainage channel infilling with grasses.

Channel infilling with gravel

4 N_0 Horizontally bedded sandstone, full bank height.

Seismic line appears to have had cover removed by dozing and has degraded about 2'. Water flowing in channel. Probed 18" and stopped in granular material but could have been frozen ground. See Picture 10.



LAT. 69°40'
LONG 146° 50'
AVE. ALTITUDE 800'
MEAN ANNUAL AIR TEMP. 10°F

SITE NO. 4 SHEET NO. 83
PLATE NO. 12

Picture: 1 Location of hole 4 G_T at centre of polygon
Site: 4 G_T

Picture: 2 Drilling hole 4 H_T on ridge of polygon. Hummocky surface in foreground.
Site: 4 H_T

Picture: 3 View of the flat SP terrain with the pond at hole 4 C_T
Site: 4 C_T

Picture: 4 Location of hole 4 B_T close-up of vegetation.
Site: 4 B_T

Picture: 5 View of the hummocky terrain looking towards outwash hill from hole 4 D_T.
Site: 4 D_T

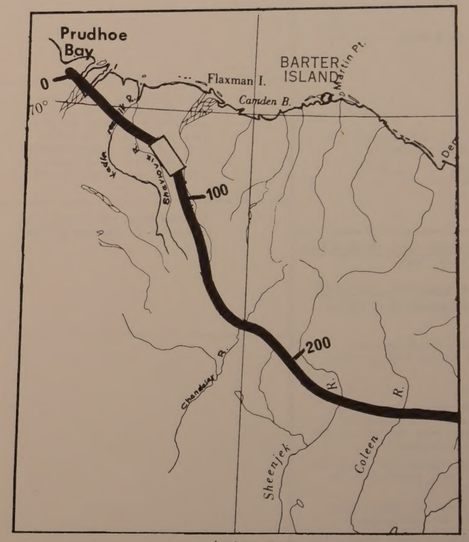
Picture: 6 Gravel on the flood plain of Kavik River at site 4 F_0.
Site: 4 F_0

Picture: 7 View of the terrain at hole 4 E_T. Note darker coloration of moss and lichen.
Site: 4 E_T

Picture: 8 Looking north from top of sandstone mesa.
Site: 4 A_0

Picture: 9 River bank, soft wet fractured claystone overlain by gravel.
Site: 4 M_0

Picture: 10 Seismic line turned into drainage course.
Site: 4

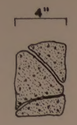


Pictures taken in late August, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE		
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	TITLE: Photo Mosaic and Terrain Investigation MILE 58 TO MILE 79		
	SUBMITTED: R Jewell	DATE: Dec/70	SITE No.: 4
	APPROVED: Lundgren	DATE: Dec/70	SHEET No.: 83
			PLATE No.: 13

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ICE-

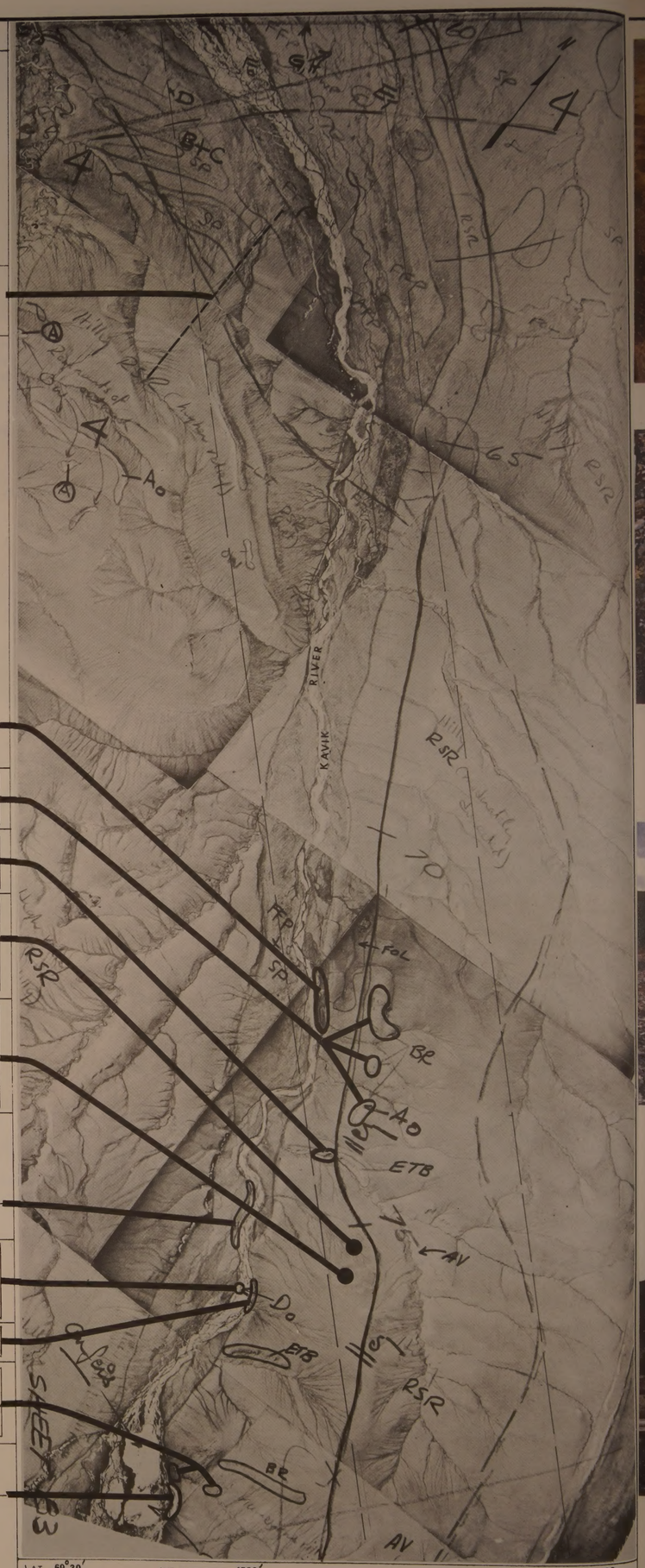
				Seismic line on the west side of the Kavik River south of Site 4 A_0 has degraded to a depth of about 10', Picture 1. A cavern formed by water erosion and melting of ice extends about 15 to 20' under the east side of the ditch, Pictures 2 and 3.
				Shale outcrop; dip of bedding 10° to south.
				5 A_0 Ridges are grey in color, and give the impression of a bedrock outcrop similar to 4 1 Sheet 84. Surface examination reveals a mixture of silty sand and subangular gravel (5 $A_0$2) Picture 4.
				5 E_0 Thaw bank exposure, coarse gravel over fractured shale, Picture 5.
5 B_T	Gully bottom is smooth from a macro-view but from a micro-view, it is composed of grass tussocks about 8" in height with a 3" moss carpet between the tussocks. Other vegetation comprises a few dwarf shrubs.	0 - 13"	ORGANIC, moss, grass, fibrous peat	5 B_T Testhole located in gully bottom elevation 1350'. Surface cover shown in Picture 6.
		13" - 8'	SILT, ice inclusions, (Vx, Vr)	
		8' 9½'	ICE, silt inclusions	
		9½' - 18'	SILT, ice lenses and inclusions (Vx, Vr)	
		18' - 20'	SHALE, ice inclusions but not excessive	
5 C_T	On ridge about 400' above 5 B_T. Vegetation is the same as for 5 C_T.	0 - 4"	ORGANIC, moss	5 C_T Testhole located on ridge about 5 B_T elevation 1750'
		4" - 6'	SILT, frozen at 14", ice inclusions (Vx, Vr)	
		6' - 9'	ICE, silt inclusions	
		9' - 11'	SILT, ice inclusions, few shale pebbles (Vx, Vr)	
		11' - 14'	ICE	
		14' - 15'	SILT, ice inclusions	
		15' - 20'	SHALE, minor visible ice	
				Steep stable banks.
				5 D_0 Active flood plain of the Kavik River (note aufeis) Picture 7. Flood plain materials are quite well-graded sand, gravel & boulders up to a maximum of 10". A white substance on the aufeis is probably rock flour and may be either wind or water deposited.
				Exposed shale outcrop with horizontal bedding on east bank of the Kavik River, Picture 8.
				5 F_0 Sand and gravel exposure along 20' high bank of small drainage course, Picture 9.
				5 G_0 Shale exposure; badly weathered surface; Pictures 10 & 11.

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

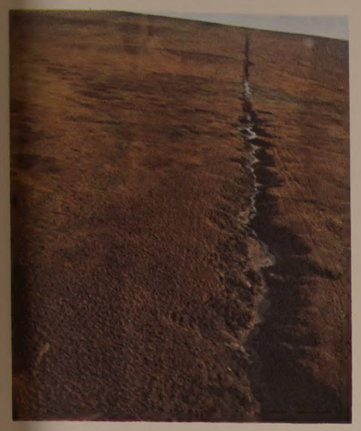
MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
AFP	Active flood plain; mainly exposed sand, gravel and cobbles with boulders locally
AV	Asymmetric valleys
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and sub-rounded in foothill regions
ETB	Steep, eroding thaw banks, includes banks containing silt, sand, gravel, till or bedrock
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel
FOL	Filled former oriented lakes; mainly thin ice-rich peat and organic silt over sand and gravel or till
IWP	Ice-wedge polygons; mainly developed in ice-rich silty deposits
OW	Glacial outwash; mainly sand and gravel with minor silt, often with thin silt mantle
RSR	Smoothly rolling silt-mantled sand and gravel, till, or bedrock plains; mainly redeposited loess consisting of thin ice-rich organic silt with occasional organic bands
SP	Speckled pattern of small ponds on undulating to rolling plain; mainly thin to thick ice-rich loessial silt over till or bedrock or sand and gravel

SEE PLATE No 3 for a comprehensive description of symbols.



LAT. 69°30' AVE. ALTITUDE 1500'
LONG. 146°40' MEAN ANNUAL AIR TEMP. 10°F

SITE NO. 5 SHEET NO. 83
PLATE NO. 14



Picture: 1
Lower end of seismic line Picture taken from 200' above ground.

Picture: 2 Deterioration of seismic line. Note cavern.

Picture: 3 Deterioration of seismic line. Note ice in cavern.

Picture: 4 Surface exposure of gravel

Site: 5 A_o

Picture: 5 Thaw bank - gravel over shale.

Site: 5 E_0

Picture: 6 Close-up of vegetation

Site: 5 B_T

Picture: 7 Active flood plain gravel, Kavik River
Note: Aufeis & white deposit on rocks

Site: 5 D_o

Picture: 8 East bank of Kavik River. Shale outcrop shows horizontal bedding

Site: 5 D_0

Picture: 9 Sand and gravel exposure along drainage course

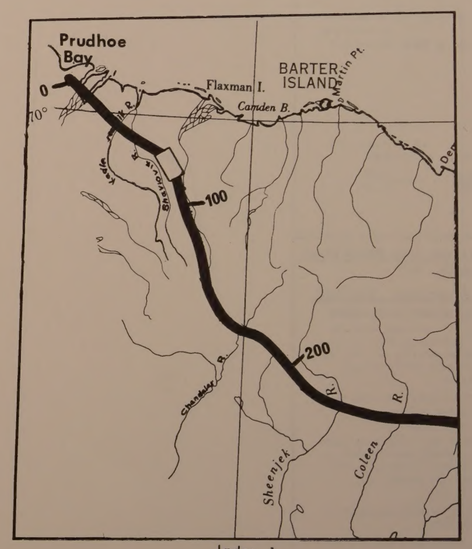
Site: 5 F_o

Picture: 10 Weathered shale outcrop, east bank of Kavik River

Site: 5 G_o

Picture: 11 Weathered shale outcrop, east bank of Kavik River.

Site: 5 G_o



Index 1

Pictures taken in late August, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON CALGARY REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

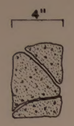
PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 58 TO MILE 79

SUBMITTED	DATE	SITE No.	PLATE No.
R Jewell	Dec/70	5	15
APPROVED	DATE	SHEET No.	
Ewspeer	Dec/70	83	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

Ndn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ICE-

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
RSR	Smoothly rolling silt-mantled sand and gravel, till, or bedrock plains; mainly redeposited loess consisting of thin to thick ice-rich organic silt with occasional organic bands
ETB	Steep, eroding thaw banks; includes banks containing silt, sand, gravel, till or bedrock
SP	Speckled pattern of small ponds on undulating to rolling plain; mainly thin to thick ice-rich loessial silt over till or bedrock or sand and gravel
IWP	Ice-wedge polygons; mainly developed in ice-rich silty deposits
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions
AFD	Variable-textured alluvial fans; mainly thin silt over sand and gravel with major textural variations often inferrable from local geomorphic (depositional) setting
OW	Glacial outwash; mainly sand and gravel with minor silt, often with thin silt mantle
FOL	Filled former oriented lakes; mainly thin ice-rich peat and organic silt over sand and gravel or till
AV	Asymmetric valleys
LST	Solifluction sheets and lobes; mainly thin silt over bedrock

SEE PLATE No 3 for a comprehensive description of symbols.

Gravel exposed on surface. Area dotted with numerous small holes, probably from burrowing animals.

Gravel exposed; does not appear to be derived from weathered bedrock.

Gravel exposed in streambed. Pictures 1 and 2 show faintly "patterned" ground adjacent to stream in Picture 1 and gravel exposed in streambed in Picture 2.

Sandstone outcrop

Shale with interbedded coal seams

Approximate location of small slope failure seen in Picture 3.

Extensive solifluction lobes and small slope failures.

Sandstone outcrop

Shale outcrops

Gravel exposed in the surface of knobs projecting above the smooth surface of RSR terrain.

Gravel exposed in streambeds.

Gravel exposed on the surface of knobs or "bumps" on RSR terrain, gravel does not appear to be derived from bedrock outcrops.

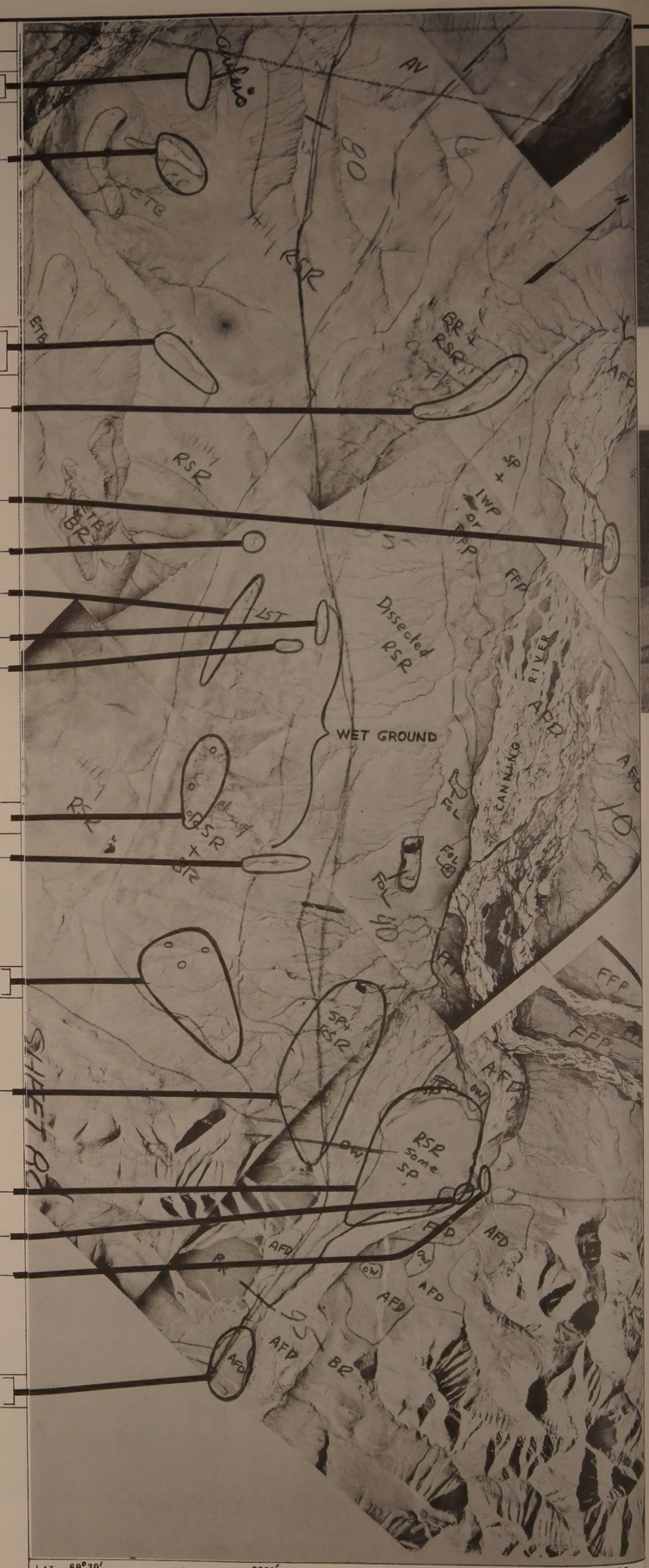
Faintly defined ice-wedge polygons in SP terrain.

Gravel terrace.

Rock nose, Picture 4.

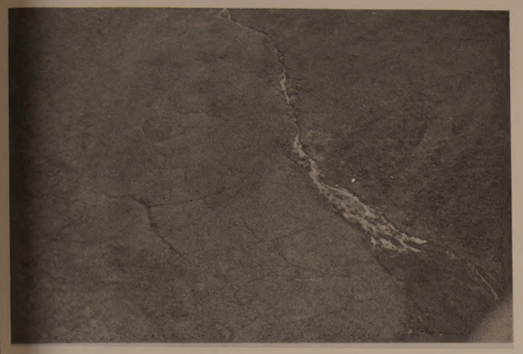
Shale outcrop, Picture 5.

Narrow river terraces and mountain slopes along Canning River,



LAT. 69°30′ LONG. 146°20′ AVE. ALTITUDE 2200′ MEAN ANNUAL AIR TEMP. 10°F

SITE NO between SHEET NO. 82 5 & 6 PLATE NO. 16



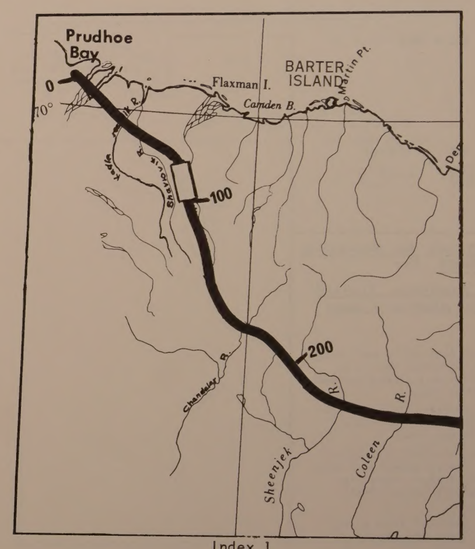
Picture: 1 Faintly patterned ground adjacent to stream.
Between Site 5 & 6

Picture: 2 Gravel exposed in streambed
Between Site 5 & 6

Picture: 3 Solifluction slump
Between Site 5 & 6

Picture: 4 Rock nose looking downstream
Between Site 5 & 6

Picture: 5 Shale outcrop
Between Site 5 & 6



Index 1

Pictures taken in late August, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON CALGARY REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 79 TO MILE 99

SUBMITTED	DATE	SITE No.	PLATE No.
R Jewell	Dec/70	between 5 & 6	17
APPROVED	DATE	SHEET No.	
Cudgeen	Dec/70	82	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE.

Nf POORLY BONDED

Ndn WELL BONDED — NO EXCESS ICE

Nde WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK.

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

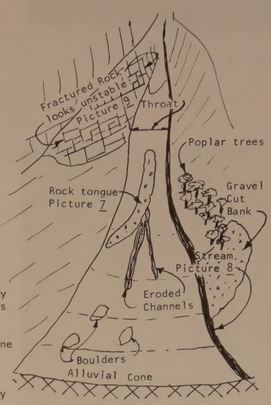
J. D. Mollard and Associates Limited

MAP SYMBOL — ABBREVIATED DESCRIPTION OF TERRAIN

- BR - Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and sub-rounded in foothill regions
- AMX - Alpine moraine complex; mainly bouldery coarse till associated with multiple glaciations of Brooks Range
- AFD - Variable-textured alluvial fans; mainly thin silt over sand and gravel with major textural variations often inferrable from local geomorphic (depositional) setting
- FFP - "Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel
- ACD - Alluvial cones; mainly poorly sorted boulders to silt sizes with major textural variations often inferrable from local geomorphic setting
- TS - Talus slope; mainly poorly sorted deposits containing large boulders, gravel, sand and silt at the base of steep mountain or valley slopes

SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
6 E_T & F_T			It was not possible to hand-excavate a testpit or drill a testhole due to coarse rock debris. Alluvial cone is concave, Picture 3. Bottom of slope = 17° Center of slope = 20° Top of slope = 22° Cover is moss and bushes to 4' in height. Bushes appear to parallel contours of the cone, Picture 4. Rock outcrops, Picture 5 and large boulders, Picture 6 on surface of cone. Note small erratic rocks on top of large boulder in Picture 6. A rock "tongue," Picture 7 taken from the throat of the cone. A stream bed is located on the northerly edge of the cone. Bank of the stream is composed of sand and gravel, Picture 8. Rock outcrop above the throat of the cone is badly fractured indicating extensive ice-jacking, Picture 9. This cone is considered to be moderately active with deposition by stream action in the summer and snow avalanche actively in the winter. Excavation could be accomplished by bulldozer.
6 Between E_T and B_o			Vegetation comprises moss, broadleaf plants and dwarf shrubs, Picture 10. Rock tongues and rock piles occur as shown in Picture 11.
6 B_o			Accumulation of debris at base of steep rock slope appears to be inactive, Picture 12. At base of the debris a fan-like deposit occurs with striations as shown in Picture 13.
6 C_T	Slightly hummocky ground with grass growth and very little moss. Few exposed boulders.	0 - 6" ORGANIC, silty, rootlets 6" - 5½' SILT, grey, no visible ice unfrozen 5½'- Encounter boulder or bedrock	6 C_T AMX terrain between rock outcrops, Picture 15.
6 A_o			Active flood plain sand and gravel, derived from dolomites and limestones, Picture 14. Material is gap-graded with subrounded boulders to 8". Sand is salt and pepper color. Riverbed is actively aggrading.



Mountainous terrain of Brooks Range shows rock bedding, Picture 1.

Broad braided river channel, Picture 2.

River bank is bedrock.

River erosion at toe of cone.

Drainage course degrading.

Terrace 50' high

Heavy tree cover on this river terrace.

River eroding bank

Extensive weathering of slope.

LAT. 69°10'
LONG 145°40'

AVE. ALTITUDE 2100'
MEAN ANNUAL AIR TEMP. 10°F

SITE NO. 6 SHEET NO. 81
PLATE NO. 18

Picture: 1 Mountainous terrain at start of Brooks Range.

Picture: 2 Broad braided river channel.

Picture: 3
View of cone looking up slope toward the throat.
Site: $6E_T$ & F_T

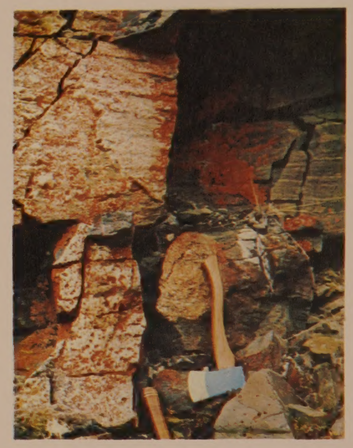
Picture: 4 Bushes appear to parallel contours of cone. Picture looking across cone.
Site: 6 E_T & F_T

Picture: 5 Rock pockets on surface of cone.
Site: 6 E_T & F_T

Picture: 6 Large boulder with smaller rocks deposited on top (avalanche powder)
Site: 6 E_T & F_T

Picture: 7 Rock tongue
Site: 6 E_T & F_T

Picture: 8 Stream bed on northerly edge of cone.
Site 6 E_T & F_T



Picture: 9
Fractured rock above throat of cone.
Site: $6E_T$& F_T

Picture: 10 Vegetation on slope
Site: 6 between E_T & B_o

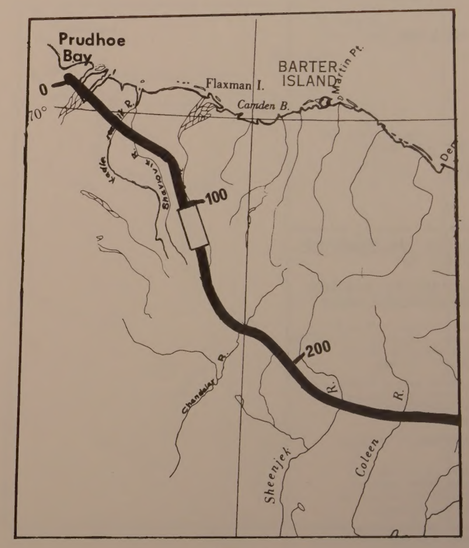
Picture: 11 Rock tongues
Site: 6 between E_T & B_o

Picture: 12 Accumulation of vegetation covered debris below steep rock slope.
Site: 6 B_0

Picture: 13 Fan-like deposit with striation pattern.
Site: 6 B_o

Picture: 14 Active flood plain gravels
Site: 6 A_0

Picture: 15 Test hole location between rock outcrops
Site: 6 C_T



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Pictures taken in late August, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	TITLE: Photo Mosaic and Terrain Investigation MILE 99 TO MILE 124
SUBMITTED: R Jewell DATE: Dec/70	SITE No.: 6 PLATE No.: 19
APPROVED: Cudgeon DATE: Dec/70	SHEET No.: 81

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Ndn WELL BONDED — NO EXCESS ICE

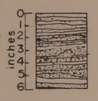
Nde WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS



Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ▒ ICE- □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

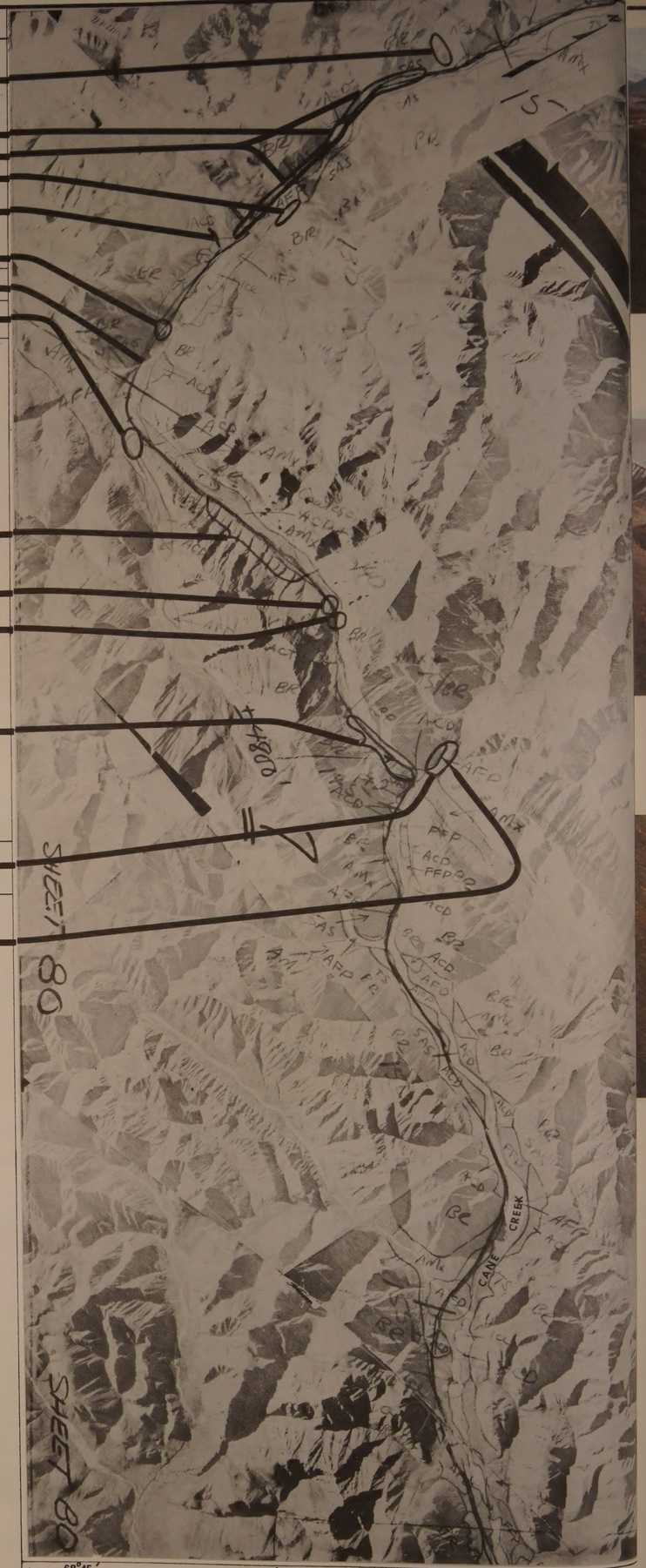
MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions
ACD	Alluvial cones; mainly poorly sorted boulders to silt sizes with major textural variations often inferrable from local geomorphic setting
SAS	Steep avalanche-susceptible mountainsides
TS	Talus slope; mainly poorly sorted deposits containing large boulders, gravel, sand and silt at the base of steep mountain or valley slopes
AFP	Active flood plain; mainly exposed sand, gravel, and cobbles with boulders locally
AFD	Variable-textured alluvial fans; mainly thin silt over sand and gravel with major textural variations often inferrable from local geomorphic (depositional) setting
AMX	Alpine moraine complex; mainly bouldery coarse till associated with multiple glaciations of Brooks Range
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel

SEE PLATE No 3 for a comprehensive description of symbols.

		7 A_o	Approximate location of "dike."
			Old alluvial cone extends nearly across river. Picture 1.
			Active steep talus slopes
			Vertically jointed rock eroding in this area.
			"Dike"
			Active alluvial cone.
			Valley slopes and Canning River immediately downstream of bend in passage, leading toward summit, Picture 2.
			Fractured limestone or dolomite, Picture 3, at rock nose.
			Rugged canyon walls, Picture 4.
			Canyon section approaching summit from west side, Picture 5.
			Summit of pass through canyon section - elevation 5000', Picture 6.
			Canyon section east side of summit toward Cane Creek, Picture 7.
			Active flood plain; gap-graded gravels with subangular boulders to 2½', Picture 8. Rock types include limestone, argillaceous quartzite and chert conglomerate.
			Active talus slope, Picture 9.

Notes On Canyon Section

1. Talus activity high through 10-mile section of canyon
2. Snow avalanche activity potential high when snow depth is in excess of 30".
3. Canyon section appears too narrow and talus activity too great for normal pipeline construction.



LAT. 68°45′
LONG. 145°15′

ALTITUDE 5000′ at summit.
MEAN ANNUAL AIR TEMP. 10°F

SITE NO. 7 SHEET NO. 80
PLATE NO. 20

Picture: 1 Alluvial cone.

Site: 7 Mile 134

Picture: 2 Approaching junction in valley. Note location of passage towards summit.

Site: 7 Mile 135

Picture: 3 Close-up of fractured rock.

Site: 7 Mile 136

Picture: 4 Right-of-way side of canyon, showing rugged slopes.

Site: 7 Mile 137-140

Picture: 5 Canyon section approaching summit.

Site: 7 Mile 140

Picture: 6 Summit of the pass through canyon section of proposed route Elevation 5000'.

Site: 7 Mile 140

Picture: 7 Canyon section east side of summit towards Cane Creek

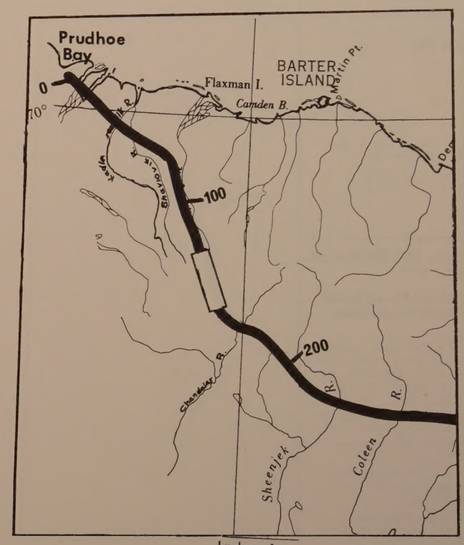
Site: 7 Mile 141-143

Picture: 8 Active flood plain, gap-graded gravels with boulders to 2½'.

Site: 7 Mile 144

Picture: 9 Active talus slope

Site: 7 Mile 144



Index 1

Pictures taken in late August, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 123 TO MILE 160

SUBMITTED	DATE	SITE No.	PLATE No.
R Jewell	Dec/70	7	21
APPROVED	DATE	SHEET No.	
G.W. Speer	Dec/70	80	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
SEGREGATED ICE NOT VISIBLE BY EYE				
Nf POORLY BONDED	8 A_T	Grass and moss hummocks, Picture 1 with free standing water between. Sparse spruce growth up to 5' in height. Close-up of grass growth shown in Picture 2.	0 - 2' ORGANIC, moss & silt, frozen below 2' 2' - 7' SILT, small pebbles, ice inclusions (Vx, Vr) 7' - 8' Large boulder or bedrock; could not advance drill.	8 A_T Testhole on inactive flood plain, middle terrace above the river. Pictures 1 & 2.
Ndn WELL BONDED — NO EXCESS ICE	8 A_{T_1}			River terraces in vicinity of 8 A_{T_1}. Picture 3 panorama view from middle to upper terrace is dry ground composed of clean sand and gravel which appears to have been water sorted. Middle terrace is wet with free standing water, see testhole 8 A_T. Lower terrace has numerous large boulders exposed by small creek. Willow growth to 10' on lower terrace. Terrace suggests Cane Creek to have been degrading at one time.
Nde WELL BONDED — EXCESS ICE				Talus deposits at base of slope.
				River eroding bedrock outcrop.
	8 B_0			Active flood plain; sand and gravel are fairly well graded, but lack sand sizes. River aggrading at the present time. Rock types are limestone, chert, argillite and schistose chert conglomerate.
VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK				
Vx INDIVIDUAL ICE INCLUSIONS	8 D_T	Marshy area with grass and moss hummocks. Free standing water between hummocks. Very sparse spruce trees to 20' in height.	0 - 1½' ORGANIC, moss & silt, frozen below 1½' 1½' - 5' SILT, some pebbles, ice lenses and inclusions (Vx, Vr) till-like 5' - 6' Boulder or bedrock; could not advance drill.	8 D_T Testhole in marshy lower area, Picture 4.
Vc ICE COATINGS ON PARTICLES				
Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS	8 C_T	Dry ground with very sparse grass and moss cover. Mineral soil and boulders exposed on the surface in patches.	0 - 2" ORGANIC 2" - 1' SILT, organic, some shaley gravel. 1' - 2' SAND & GRAVEL, silty, frozen no visible ice 2' Boulder or bedrock; could not advance drill.	8 C_T Testhole located on dry ground, Picture 5. Material in general area is sandy silt with till-like angular gravel plastered over highs and filled-in lows. Scattered erratic boulders up to 3' in diam. are exposed on the surface. Frost boil-like remnants are numerous on dry surfaces in area, Picture 6. Rock deposits to south west of Hole 8 C_T, Picture 7. It was not possible to determine, without a major excavation, whether this rock is the result of ice-wedging action in bedrock or was deposited during an avalanche.
Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS				
	8 F_0			Limestone rock badly fractured, Picture 10.
	8 E_0			Solifluction activity quite high particularly on slope 1 horizontal to 1 vertical; mineral soil is exposed and some low willow bushes, partly overturned, Picture 8. Overall view of slope movement shown in Picture 9.
				Active cone.
				Limestone exposures
VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK				
ICE & SOIL ICE WITH SOIL INCLUSIONS	8 G_0			Rock above TS terrain is chert. TS terrain below appears to be a talus with moss cover and dwarf shrubs.
				Very wet area, gravel showing in lake bottom.
ICE ICE WITHOUT SOIL INCLUSIONS	8 H_0			Circular lake with banks up to 60' high. Soil-type appears to be a mixture of silt and subangular gravel (till of alpine morainal complex). Slumping occuring at several points around lake, Pictures 11 and 12.
				Small lakebed.
	8 I_0			Moss and grass tussocks, occasional boulders and frostboil-like mounds; few inches high and 3' across, frozen below 18"
	8 J_0			Hummocks 1' in diam. with free standing water between; very wet, frozen below 14".

LEGEND: SOIL — ICE —

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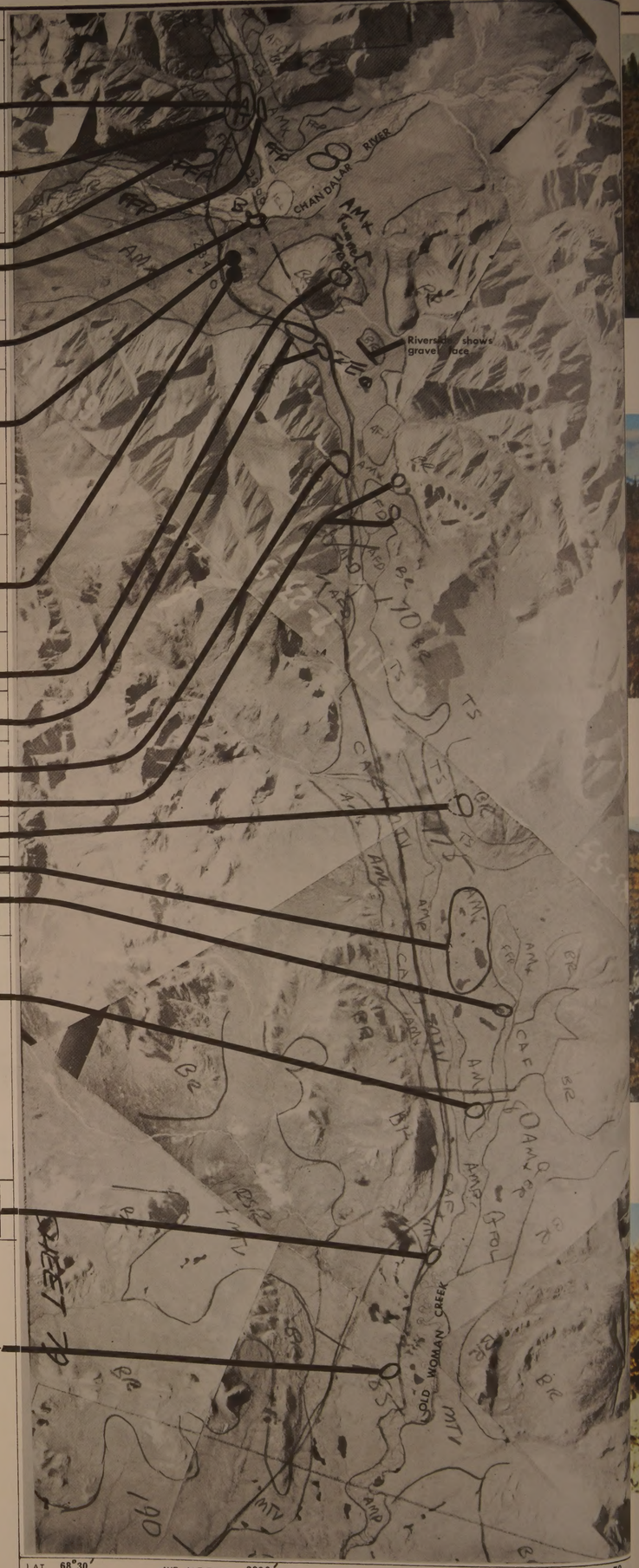
MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
AFD	Variable-textured alluvial fans; mainly thin silt over sand and gravel with major textural variations often inferrable from local geomorphic (depositional) setting
TS	Talus slope; mainly poorly sorted deposits containing large boulders, gravel, sand and silt at the base of steep mountain or valley slopes
AMX	Alpine moraine complex; mainly bouldery coarse till associated with multiple glaciations of Brooks Range
FFP	"Fossil" (i.e., inactive) flood plain mainly thin silt over sand and gravel
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions
FOL	Filled former oriented lakes; mainly thin ice-rich peat and organic silt over sand and gravel or till
MTV	Smooth streaked slopes in foothill localities; mainly thick ice-rich organic silt (loessial) with minor sand and gravel inclusions on extensive, flatter lower slopes to thin colluvial or residual bouldery to gravelly silt over bedrock below base of bedrock slopes, with stratigraphy often inferrable from local geomorphic setting
RSR	Smoothly rolling silt-mantled sand and gravel, till, or bedrock plains; mainly redeposited loess consisting of thin to thick ice-rich organic silt with occasional organic bands

SEE PLATE No 3 for a comprehensive description of symbols.



LAT. 68°30′ LONG. 144°30′ AVE. ALTITUDE 3000′ MEAN ANNUAL AIR TEMP. 12 °F

SITE NO. 8 SHEET NO. 78 PLATE NO. 22

Picture: 1 Overall view of surface cover at testhole site

Site: 8 A_T

Picture: 2 Close-up of grass cover

Site: 8 A_T

Picture: 3 Panorama middle to upper terrace viewed from left to right.

Site: 8 A_T

Picture: 4 General view of testhole location in marshy ground to left.

Site: 8 D_T

Picture: 5 Dry ground, sparse vegetation cover at hole location

Site: 8 C_T

Picture: 6 Frost boil-like remnants on dry ground surface.

Site: 8 C_T

Picture: 7 Rock debris.

Site: 8 C_T

Picture: 8 Close-up view of solifluction lobe.

Site: 8 E_0

Picture: 9 Over-all view of slope movement. Note aufeis.

Site: 8 E_0

Picture: 10 Limestone outcrop badly fractured.

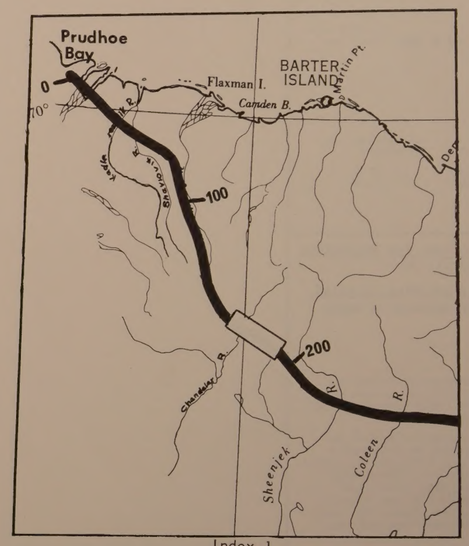
Site: 8 F_o

Picture: 11 Banks of lake showing recent slump.

Site: 8 H_o

Picture: 12 Close-up of material in bank of lake. Exposure is scarp of slump.

Site: 8 H_0



Index 1

Pictures taken in late August, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 158 TO MILE 190

SUBMITTED	DATE	SITE No.	PLATE No.
L Jewell	Dec/70	8	23
APPROVED	DATE	SHEET No.	
Curlspeer	Dec/70	79	

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Ndn WELL BONDED – NO EXCESS ICE

Nbe WELL BONDED EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

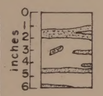
Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Ve STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL – ICE –

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

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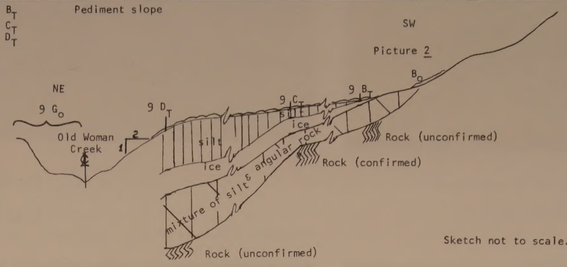
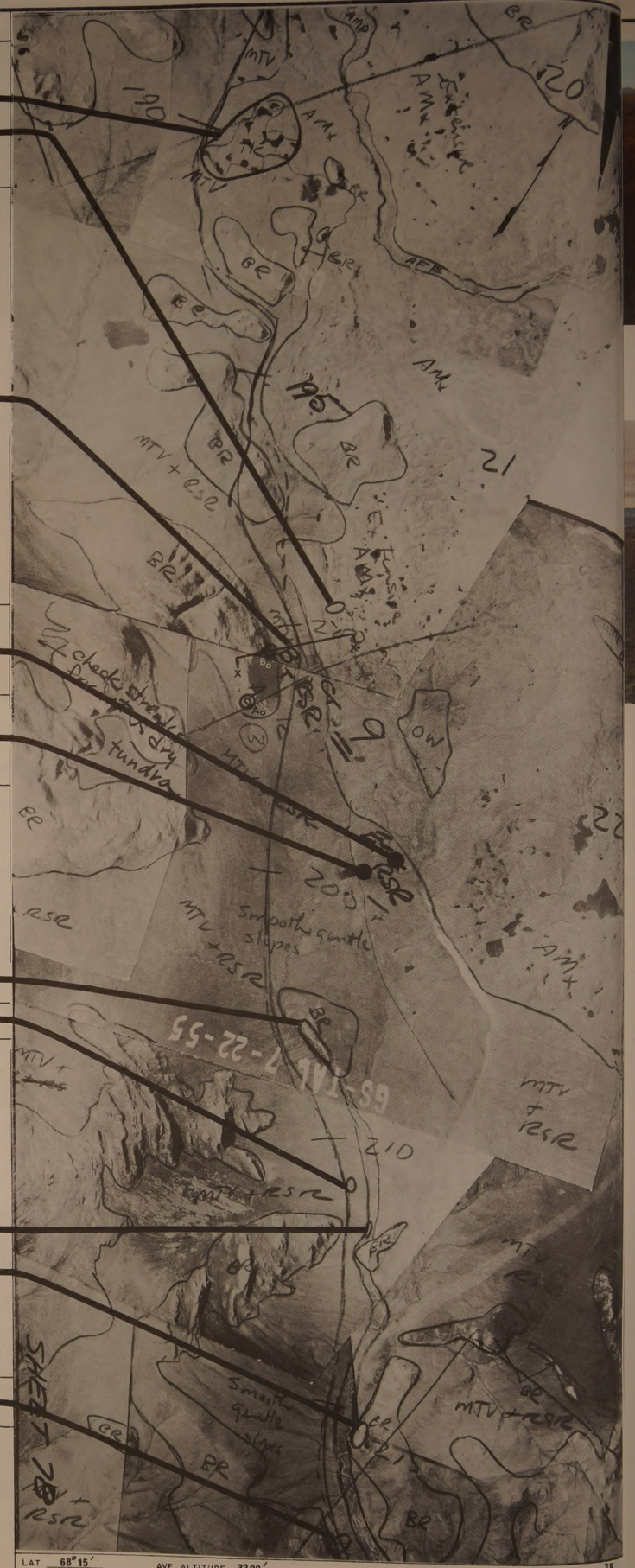
MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and sub-rounded in foothill regions
MTV	Smooth streaked slopes in foothill localities; mainly thick ice-rich organic silt (loessial) with minor sand and gravel inclusions on extensive, flatter lower slopes to thin colluvial or residual bouldery to gravelly silt over bedrock below base of bedrock slopes, with stratigraphy often inferrable from local geomorphic setting
RSR	Smoothly rolling silt-mantled sand and gravel, till, or bedrock plains; mainly redeposited loess consisting of thin to thick ice-rich organic silt with occasional organic bands
OW	Glacial outwash; mainly sand and gravel with minor silt, often with thin silt mantle
AMX	Alpine moraine complex; mainly bouldery coarse till associated with multiple glaciations of Brooks Range
AMP	Actively meandering flood plain- mainly ice-rich silt and fine sand

SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE
9 B_T	Silt hummock with a cover of grass, moss and lichen. Dwarf willows, bushes 2' in height.	0 - 1' ORGANIC, moss and silt, frozen below 12" 1' - 3' ICE, silt inclusions 3' - 11' SILT, gravelly, ice inclusions (Vr) 11' - 12' Boulder or bedrock
9 C_T	Silt hummocks with a cover of grass and moss. Dwarf willow bushes to height of about 2'.	0 - 2' ORGANIC, silt and moss frozen below 18" 2' - 5' ICE, silt inclusions 5' - 11' SILT, sand & gravel, ice lenses , Vx 11' - 19' Bedrock
9 D_T	At crest of 2 horizontal to 1 vertical slope. Tussocks of grass and moss and willow bushes up to 1½' in height. Surface rock identified as cemented chert breccia.	0 - 6" ORGANIC, moss 6" - 2' SILT, frozen at 14" (Vr, Vx) 2' - 4' GRAVEL, boulders 4' -11½' SILT, pebbles, ice inclusions (Vx) 11½' - 18' ICE, layer of silt at 15' 18' -22½' SAND, occasional boulders 22½' - 39' SILT, gravel, finer with depth.
9 E_T	Fairly thin organic cover of grass tussocks and some moss. Clumps of willow type bushes 3' in height.	0 - 3" ORGANIC, moss 3" - 6' SILT, gravel rounded to subangular, frozen below 6' 6' - 10' SILT, gravel, ice inclusions 10' - 19' Bedrock
9 F_T	Near edge of pond which is infilling. Moss and grass hummocks with willow bushes 3' in height.	0 - 8' ORGANIC, moss frozen below 12" 8' - 2' SILT, slightly organic (Vx) 2' - 7' ICE, silt inclusions 7' - 15' GRAVEL, silty, visible ice 15' - 19' SAND, SILT, CLAY

	RECONNAISSANCE OBSERVATION NOTES
	Small thaw ponds only slightly depressed.
9 G_0	AMX terrain 9 G_0 1 SAND & GRAVEL, silty till-like RSR terrain 9 G_0 2 SILT, slightly clayey
9 B_T 9 C_T 9 D_T	Pediment slope  Sketch not to scale. Section X-X (looking toward southeast) Slope of pediment surface is estimated in the order of 10:1. General view of pediment surface, Picture 1 showing drill at Site 9 C_T.
9 B_0	Rock debris at the toe of steep mountain slope is possibly due to ice wedging Picture 2. Rock identified as greywacke sandstone.
9 A_0	Weathered rock at top of mountain above pediment slope but to the south of 9 B_0, Picture 3. Rock identified as micaceous greywacke schist. For relative locations of 9 B_0 and 9 A_0, see Picture 4. Yellow stripes in picture are wet with free water and have the appearance of drainage courses while reddish darker areas are dry.
9 E_T	Test hole on eroded ridge.
9 F_T	Testhole at edge of closed pond.
	Rock is highly weathered, fissured, fractured and folded.
9 H_0	Shallow pit revealed silt with few rounded pebbles and cobbles. Frozen below 22".
	Bedrock outcrop.
9 I_0	Rock outcrop identified as green basalt.
9 K_0	Appears to be a pediment slope. The surface material at top of rock outcrop above pediment was identified as a limonite-stained silt with mica schist particles and fragments.



LAT. 68°15′ LONG 144°00′ AVE. ALTITUDE 3200′ MEAN ANNUAL AIR TEMP. 14 °F

SITE NO. 9 SHEET NO. 78 PLATE NO. 24

Picture: 1 General view of surface. Drill located at 9 C_T.

Site: 9 C_T

Picture: 2 Rock debris at toe of steep mountain slope.

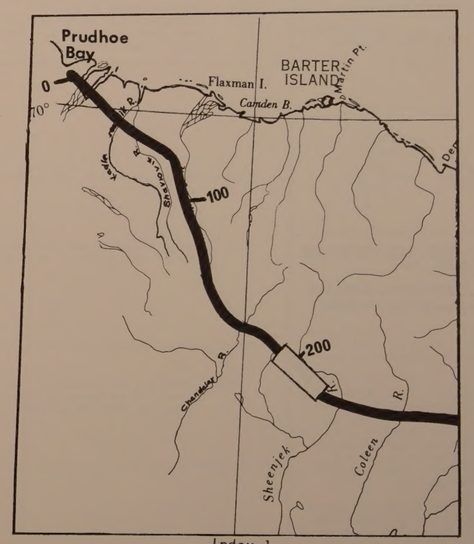
Site: 9 B_0

Picture: 3 Weathered rock at top of mountain above pediment. Note drainage courses in low land.

Site: 9 A_0

Picture: 4 Relative locations of 9 A_0 and 9 B_0. Note drainage courses extending from base of hill.

Site: $9A_0$, $9B_0$



Index 1

Pictures taken in early September, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 186 TO MILE 215

SUBMITTED	DATE	SITE No.	PLATE No.
L Jewell	Dec/70	9	25
APPROVED	DATE	SHEET No.	
Ewspeer	Dec/70	78	

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Ndn WELL BONDED — NO EXCESS ICE

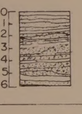
Nde WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS



Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ▩ ICE- □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL — ABBREVIATED DESCRIPTION OF TERRAIN

BR - Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions

MTV - Smooth streaked slopes in foothill localities mainly thick ice-rich organic silt (loessial) with minor sand and gravel inclusions on extensive, flatter lower slopes to thin colluvial or residual bouldery to gravelly silt over bedrock below base of bedrock slopes, with stratigraphy often inferrable from local geomorphic setting

RSR - Smooth rolling silt-mantled sand and gravel, till or bedrock plains; mainly redeposited loess consisting of thin to thick ice-rich organic silt with occasional organic bands

AMP - Actively meandering flood plain; mainly ice-rich silt and fine sand

OW - Glacial outwash; mainly sand and gravel with minor silt, often with thin silt mantle

AFP - Active flood plain; mainly exposed sand, gravel and cobbles with boulders locally

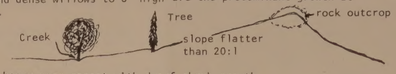
SP - Speckled pattern of small ponds on undulating to rolling plain; mainly thin to thick ice-rich loessial silt over till or bedrock or sand and gravel

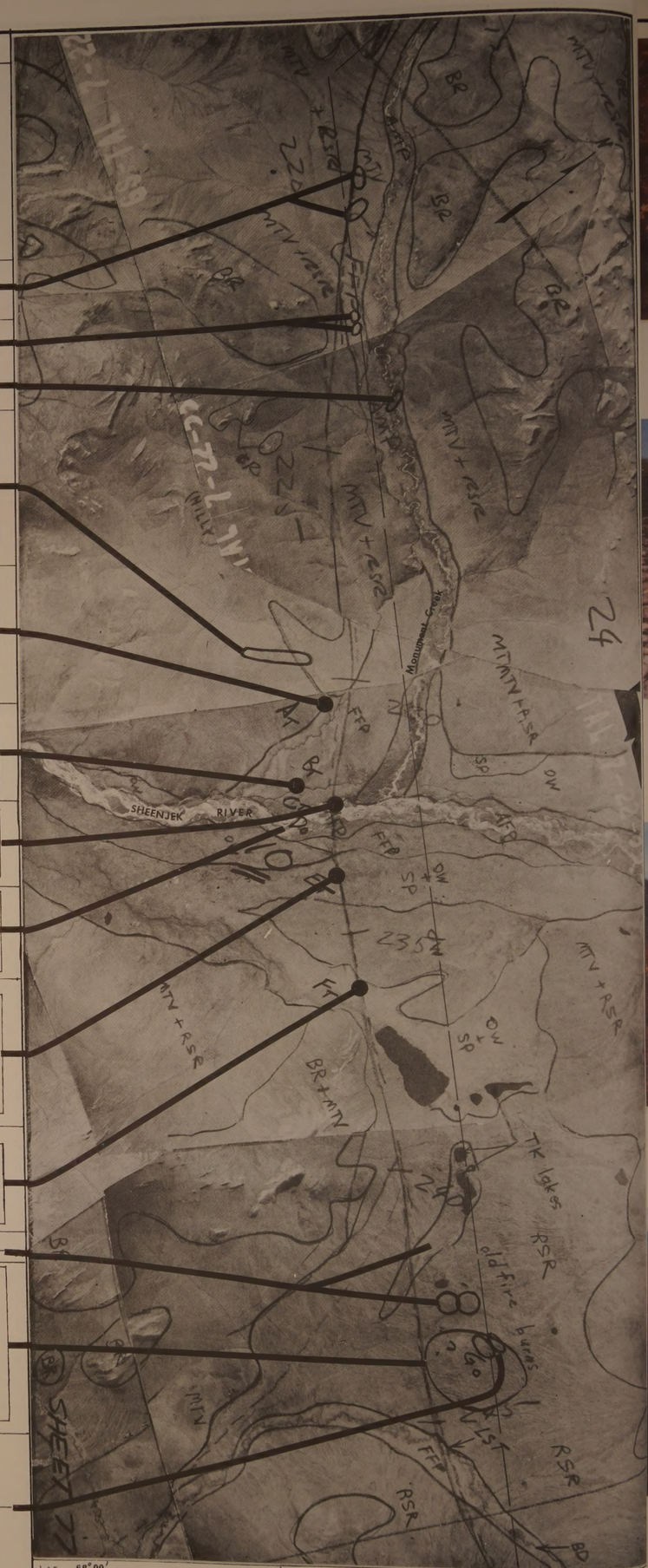
LST - Solifluction on sheets and lobes; mainly thin silt over bedrock

BD - Beaded drainage

FFP - "Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel

SEE PLATE No 3 for a comprehensive description of symbols

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
			9 J_0 Grassy hummocks about 2' in diam. and about 1' high. Standing water between hummocks. Frozen below 12" in hollows. Overall view Picture 1 and close-up of grassy hummock, Picture 2.
			Frostboil-like features
			Gravel in creek bed
			10 H_0 Small bedrock exposure on top of hill above pediment slope, as shown by sketch, and Picture 3. Sample $H_0$1 of outcrop indicates that the rock is diorite. Spruce trees 30' high and spaced 15' to 20' apart cover the lower end of the slope and dense willows to 6' high are the predominant growth at upper end of slope.  Surface cover is a heavy moss carpet with dwarf shrub growth.
10 A_T	Moss and grass hummocks 1' to 2' in diameter and 12" to 18" high. Some small bushes.	0 - 1' ORGANIC, 1' - 22' SILT, ice lenses and inclusions (Vr,Vx) frozen below 14" 22' - 27' ICE, silt lenses 27' - 29' SILT, ice lenses and inclusions (Vr,Vx) 29' - 31' SILT & GRAVEL 31' - 39' SANDSTONE	10 A_T On pediment slope. Ground surface is hummocky with some small bushes 2' to 3' in height. Spruce trees spaced at 30' and to a height of 15'.
10 B_T	Level, grass and moss hummocks. Grass hummocks 1' to 2' in diameter and 1' to 1½' in height. Sparse small bushes to 1½' in height. Some free water between grass hummocks.	0 - 1' ORGANIC, 1' - 5' SILT, ice inclusions (Vr), frozen below 14"-16" 5' - 12' SAND & GRAVEL 12' - 19' SANDSTONE	10 B_T Elevation measured to be approximately 1600'. Permafrost encountered at 8" in hollows to 18" on tufts.
10 C_T	Grass hummocks 2' to 3' in diameter and 1' to 1½' high. Moss less than at 10 B_T. Free water between hummocks.	0 - 1' ORGANIC 1' - 5' SAND, frozen below 2' (Nbn,Vx) 5' - 6' GRAVEL & SAND 6' - 10' BEDROCK or boulder.	10 C_T About 20' lower in elevation than 10 B_T.
			10 D_0 Active flood plain (AFP) of the Sheenjek River. Picture 4 is a close up of flood plain material. Rocks are subangular to well rounded, maximum to 6" gap-graded to 1" and short of fines. Rock types include conglomerates, black and green slate, quartz, limestone, and sandstone
10 E_T	Grass and moss, small hummocks, sparse small bushes 1' in height.	0 - 1' ORGANIC 1' - 3' SILT, organic, frozen below 2' (Nbe) 3' - 6' SILT, ice lenses and inclusions (Vr,Vx) 6' - 11' GRAVEL 11' - 15' SANDSTONE	10 E_T At approximately elevation 1500'. Grass on moss carpet with occasional willow growth and dwarf shrubs, Picture 5. Ground is firm.
10 F_T	Grass and moss carpet, fairly level. Sparse bushes 1' to 2' high. Two small spruce trees 6' high.	0 - 1' ORGANIC 1' - 5' SILT, ice inclusions (Vr), frozen below 14"-16". 5' - 12' SAND & GRAVEL 12' - 19' SANDSTONE	10 F_T In red dwarf birch strip at about elevation 1500'. Grass on moss carpet; spongy with much surface water. Faintly patterned ground outlined by red dwarf birch, Picture 6 & 7.
			Swampy polygonal ground
			10 G_0 Overall area has streaked pattern as shown in Pictures 8 and 9 taken from 2000' above ground surface and looks like fireburn area with Picture 10 from a lower elevation above ground surface. Many standing snags and spikes with short second growth. Scattered willows to 4'. Permafrost encountered at 20" to 24" below ground surface. Lighter streaks on terrain are hummocks of moss grass with dwarf shrubs with water between, Picture 11. Darker streaks are the drier parts and have red leaf dwarf birch, Picture 12. Spruce trees to 15' in height are scattered throughout the area.
			Spruce trees in area are to 30' in height.



LAT. 68°00' LONG 143°20'

AVE. ALTITUDE 1500'

MEAN ANNUAL AIR TEMP. 11 °F

SITE NO. 10 SHEET NO. 77 PLATE NO. 26

Picture: 1 Overall view of hummocky ground
Site: 9 J_o

Picture: 2 Close-up of grassy hummocks
Site: 9 J_o

Picture: 3 Rock (diorite) outcrop at top of pediment slope.
Site: 10 H_o

Picture: 4 Shennjek River, active flood plain gravels
Site: 10 D_o

Picture: 5 General view of grass on a moss carpet with shrubs. Ground is dry.
Site: 10 E_T

Picture: 6 Faintly patterned ground. Red leafed dwarf birch growing at perimeter of polygon shapes.

Picture: 7 Very wet grassy area, very faintly patterned ground.

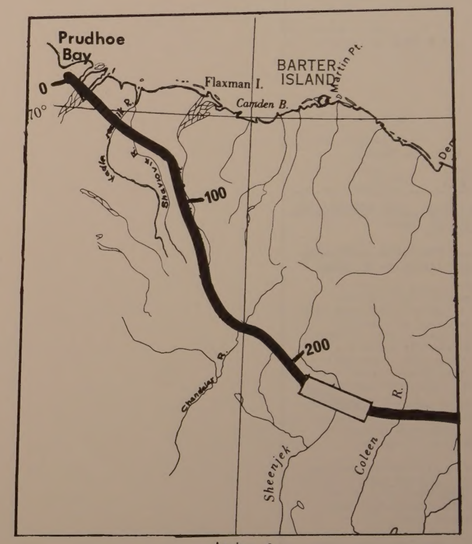
Picture: 8 Overall view of streaked pattern. Picture taken at 2000'.
Site: 10 G_o

Picture: 9 Overall view of streaked pattern. Picture taken at 2000'.
Site: 10 G_o

Picture: 10 View of streaked pattern. From lower elevation than shown in Pictures 8 & 9
Site: 10 G_0

Picture: 11 General ground view of vegetation
Site: 10 G_o

Picture: 12 Close-up of vegetation
Note: Engineer probing for permafrost depth.
Site: 10 G_0



Index 1

Pictures taken in early September, 1970

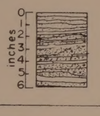
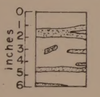
Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 215 TO MILE 246

SUBMITTED	DATE	SITE No.	PLATE No.
L Jewell	Dec/70	10	27
APPROVED	DATE	SHEET No.	
[illegible]	Dec/70	77	

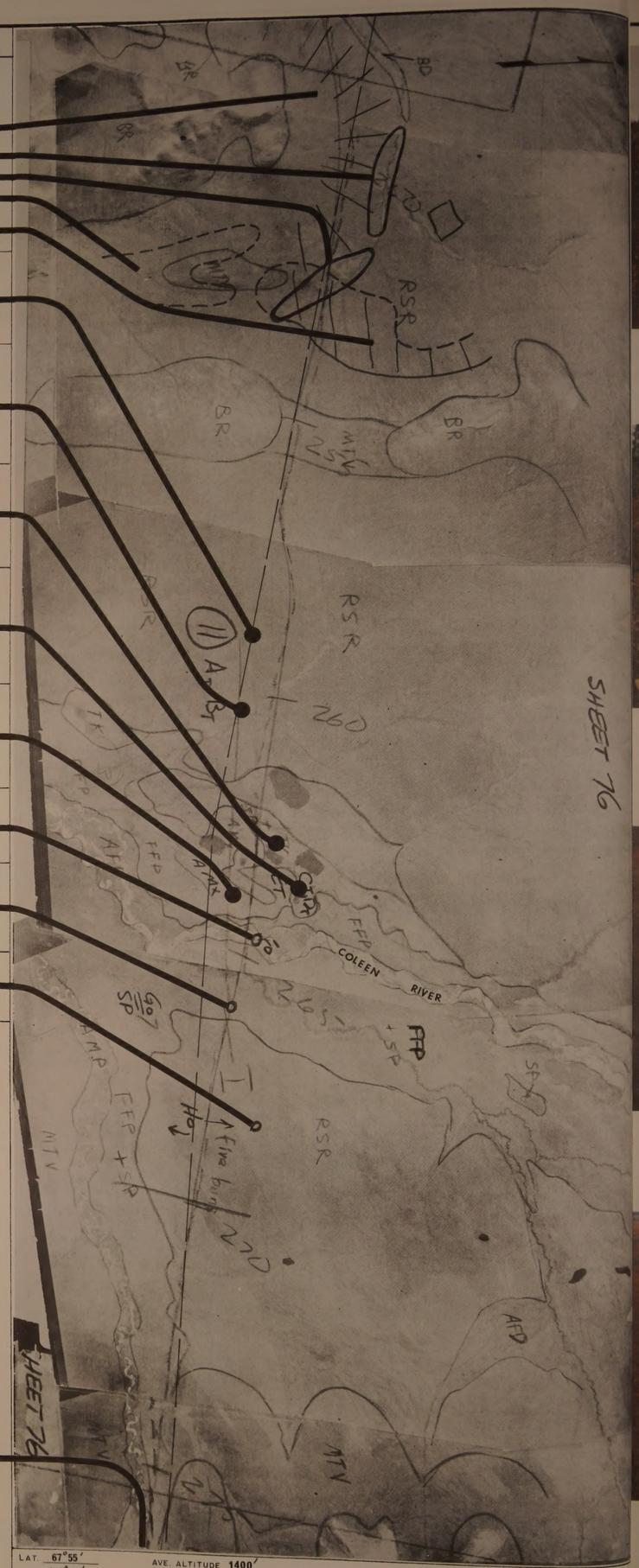
N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
SEGREGATED ICE NOT VISIBLE BY EYE				
Nf POORLY BONDED				
Nbn WELL BONDED – NO EXCESS ICE				
Nbe WELL BONDED – EXCESS ICE				
VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK				
Vx INDIVIDUAL ICE INCLUSIONS				
Vc ICE COATINGS ON PARTICLES				
Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS				
 **Vs** STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS				
VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK				
 **ICE & SOIL** ICE WITH SOIL INCLUSIONS				
ICE ICE WITHOUT SOIL INCLUSIONS				
				Strand line. Horsetail drainage pattern
				Black spruce and willow line drainage course
				Drainage course infilling
				Treed area
				Trees in alignment with (i.e.fallow) drainage pattern
	11 A_T	Grass and moss, dwarf birch and willows to 3' height. Ground slopes about 5°. Hummocks 3' to 6' in diameter and 1' to 2' in height.	0 - 15" ORGANIC, frozen below 12" 15" - 4' SILT, organic, ice lenses and inclusions (Vr) 4' - 9' SILT, sandy, pebbles. 9' - 16' SILT, SAND & GRAVEL 16' - 21' SHALE	11 A_T In RSR area, location is shown on Picture 1. The general area is covered by moss, dwarf birch and willow to 4' height; slight mounds 4' to 5' across; occasional spruce trees to 15' height.
	11 B_T	Grass hummocks 1' to 3' in diameter and 1' to 1½' in height. Few dwarf birch and willow 1' to 2' high.	0 - 6" ORGANIC, grass and moss 6" - 15' SILT, frozen below 12", ice lenses, and inclusions (Vr, Vx) 15' - 19' ICE 19' - 20' GRAVEL, silty 20' - 57' SILT, ice lenses (Vr)	11 B_T At elevation 1400' (approx.) at lower end of slope (RSR). Area is covered with grass tufts 1' across and 1' high with silt and moss exposed in between. Faint patterns on terrain are red dwarf birch, Picture 2. Sparse spruce trees 3' to 8' high. Ground slopes about 4%.
	11 C_T	Heavy moss and small bushes 1' to 2' high.	0 - 1' ORGANIC, moss 1' - 10' SILT, frozen below 12", ice lenses and inclusions (Vr,Vx) 10' - 15' SILT, organic, no visible ice 15' - 20' SILT, ice lenses and inclusions (Vr, Vx)	11 C_T On a 40' diameter, 1' high mound of moss and lichen with dwarf birch, Pictures 3 and 4. The mounds are dry, surrounded by spongy areas covered with grass tufts. The general terrain is level.
	11 D_T	Heavy lichen, moss and peat Small hummocks	0 - 1½' ORGANIC, peat and moss, frozen below 16" 1½' - 11' SILT, organic, ice lenses and inclusions (Vr, Vx) 11' - 15' ICE, silt inclusions 15' - 20' GRAVEL, minor ice inclusions (Vx)	11 D_T Hole located in patterned TK terrain at about elevation 1340'. Picture 5 shows general area with sparse spruce in background. Picture 6 shows vegetation at drill hole location.
	11 E_T	Small hummocks of grass and moss; free water between hummocks. Dwarf birch 2' to 3' high.	0 - 1' ORGANIC, grass and moss 1' - 2' SILT, organic, frozen below 14", no visible ice (Nbn) 2' - 15' GRAVEL, sandy, ice crystals (Vx) 15' - Possible bedrock	11 E_T Hole in general open area AMX. Vegetation is moss, mounds of grass and dwarf birch 2' high, Picture 7. Sparse cover of spruce in general area.
	11 F_0			On active flood plain of Coleen River; sand, gravel and cobbles to 6", gap graded. Round gravel predominately sandstone, conglomerates and limestone, Picture 8.
	11 G_0			Aerial view indicates color patterns in vegetation on Picture 9. Dwarf willow and birch up to 2' high, blueberry bushes, moss, grass tufts and mounds cover the area as shown on Picture 10. There are only few small ponds, Picture 11, in the area. There are several shallow channels in between grass mounds, and wet grass paddies about 10' across; frozen at 2-2½'. Elsewhere, the ground is frozen at about 1' depth.
	11 H_0			Fireburn area as shown by Picture 12 and 13. The terrain is covered by dwarf birch and willow to 5' height and large hummocks of moss with depressions in between, Picture 14. Scattered spruce and many old burned trees. New growth of spruce occurring in isolated areas. Occasional ponds of water 10' across.
				Gravel and sand in Woman Creek at Mile 281.

LEGEND: SOIL – ▨ ICE – □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
MTV	Smooth streaked slopes in foothill localities; mainly thick ice-rich organic silt (loessial) with minor sand and gravel inclusions on extensive, flatter lower slopes to thin colluvial or residual bouldery to gravelly silt over bedrock below base of bedrock slopes, with stratigraphy often inferrable from local geomorphic setting.
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and surrounded in foothill regions.
RSR	Smoothly rolling silt-mantled sand and gravel, till, or bedrock plains; mainly redeposited loess consisting of thin to thick ice-rich organic silt with occasional organic bands.
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel.
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand.
AMX	Alpine moraine complex; mainly bouldery coarse till associated with multiple glaciations of Brooks Range.
SP	Speckled pattern of small ponds on undulating to rolling plain; mainly thin to thick ice-rich loessial silt over till or bedrock or sand and gravel.
AMP	Actively meandering flood plain; mainly ice-rich silt and fine sand.
AFD	Variable-textured alluvial fans; mainly thin silt over sand and gravel with major textural variations often inferrable from local geomorphic (depositional) setting.
BD	Beaded drainage.



LAT. 67°55′ LONG 142°00′ AVE. ALTITUDE 1400′ MEAN ANNUAL AIR TEMP. 12° F

SITE NO. 11 SHEET NO. 76 PLATE NO. 28

Picture: 1 General view of vegetation

Site: 11 A_T

Picture: 2 Faint patterned ground outlined by red dwarf birch.

Site: 11 B_T

Picture: 3 Close-up of vegetation, moss and lichen, at drill hole.

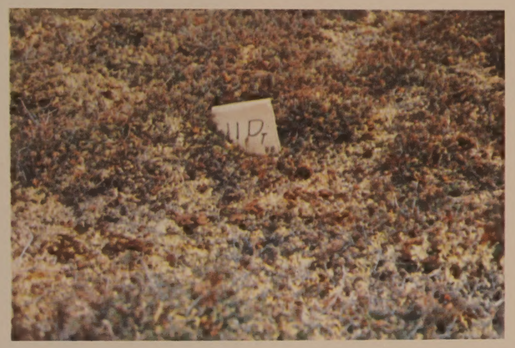
Site: 11 C_T

Picture: 4 General view of area at drill hole location

Site: 11 C_T

Picture: 5 General view, hole location in foreground. Sparse spruce trees in background, about 75' from drill hole.

Site: 11 D_T



Picture: 6 Close-up of vegetation at drill hole, heavy lichen and moss

Site: 11 D_T

Picture: 7 Moss, mounds of grass and dwarf birch at drill hole

Site: 11 E_T

Picture: 8 Close-up of gravel beach at Coleen River.

Site: 11 F_0

Picture: 9 Aerial view indicates color patterns in vegetation

Site: 11 F_0

Picture 10 Ground view of vegetation

Site: 11 G_0

Picture: 11 Small pond surrounded by sedges 1½' high.

Site: 11 G_0

Picture: 12 Aerial view of fireburn area.

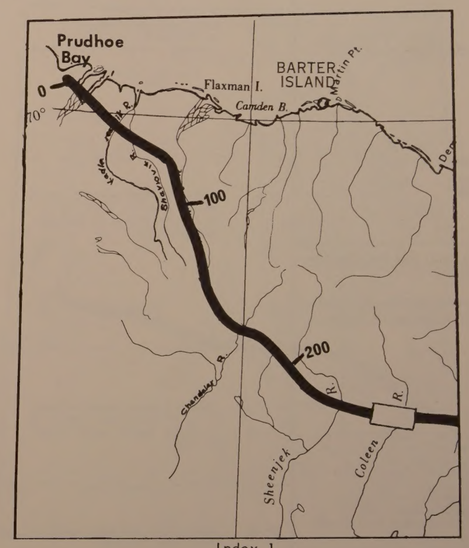
Site: 11 H_0

Picture: 13 Low level view of fireburn area.

Site: 11 H_0

Picture: 14 Ground view of vegetation, dwarf birch, willow to 5' high.

Site: 11 H_0



Index 1

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CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 246 TO MILE 275

SUBMITTED	DATE	SITE No.	PLATE No.
R Jewell	Dec/70	11	29
APPROVED	DATE	SHEET No.	
Endpeer	Dec/70	76	

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

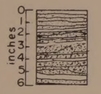
Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

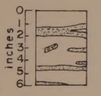
Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS



Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ICE-

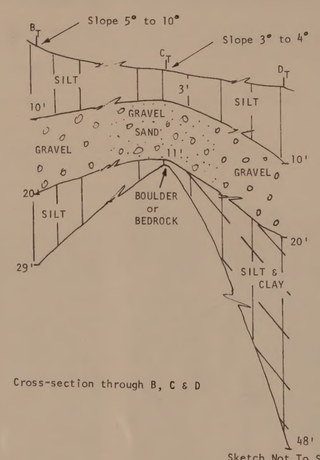
AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
MTV	Smooth streaked slopes in foothill localities; mainly thick ice-rich organic silt (loessial) with minor sand and gravel inclusions on extensive, flatter lower slopes to thin colluvial or residual bouldery to gravelly silt over bedrock below base of bedrock slopes, with stratigraphy often inferrable from local geomorphic setting.
GLB	Thick glacial-lake materials; mainly ice-rich silt and fine sand with minor clay.
RB	Raised beach ridges, spits and strand lines; gravelly to bouldery.
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel.
MK	Muskeg, swamp, marsh, bog; includes all unpatterned peatlands.
TK	Thermokarst plains; pattern of thaw ponds, and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand.
SB	String bog (ribbed fen); mainly deep peat deposits

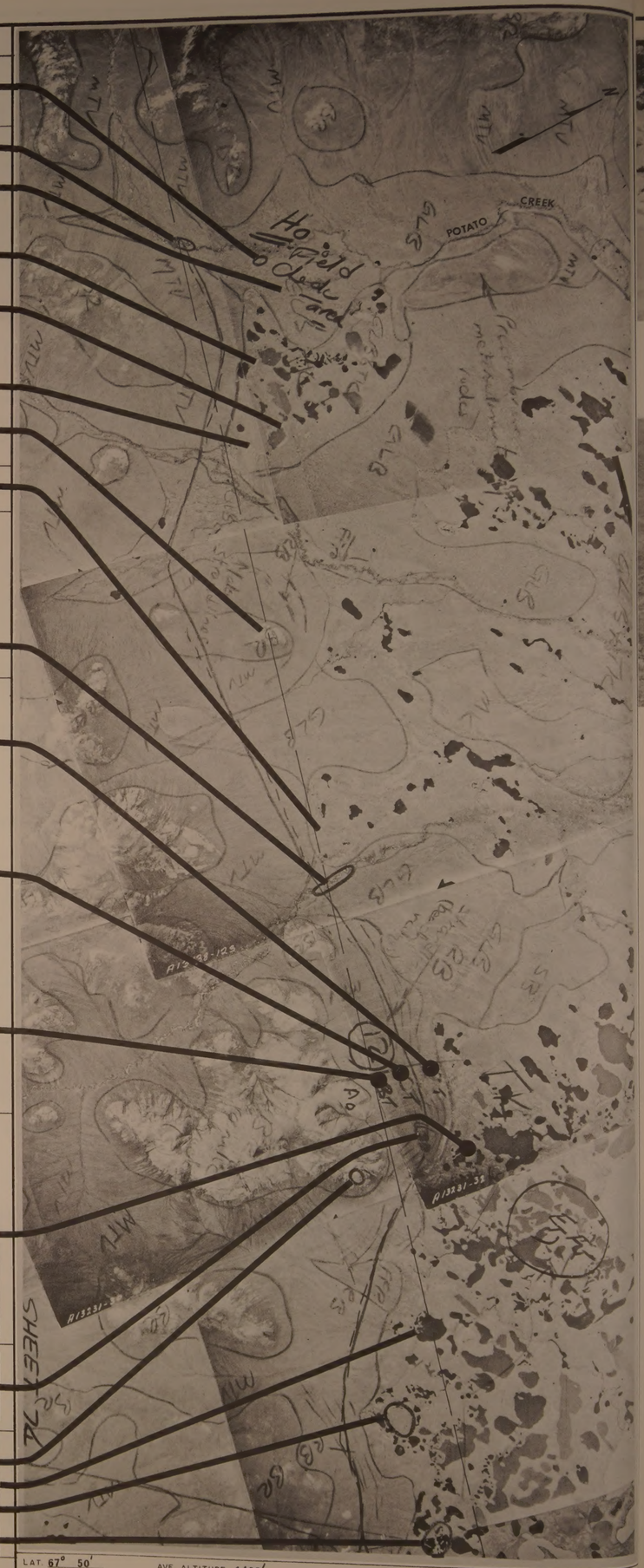
SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
			12 H_0 Dwarf willows, moss, standing water in small ponds. Also "grassed-in" areas. Believe part of speckling due to variation in color between willows (yellowish green) and red dwarf birch, which in turn appears to be related to drainage pattern.
			Sand and gravel bars in Potato Creek
			Grass infilling in old ponds
			Grass showing on water surface of lakes, suspect most ponds infilling
			Grass infilling in lake.
			Area is poorly drained.
			12 J_0 Black slate outcrop on top of knoll, Picture 1.
			Infilling lakes as shown on Pictures 2 and 3. No continuity to infilling in lakes; filling seems to be occurring from all edges.
			Some gravel in Schaeffer Creek
12 D_T	Grass and moss hummocks, bush 3' to 4' high	0 - 1' ORGANIC, moss and grass 1' - 10' SILT, clayey, frozen below 16", ice lenses and crystals (VrVx) 10' - 12' ICE 12' - 20' GRAVEL sandy, shale fragments (Nbn) 20' - 48' SILT and CLAY, pebbles, shale fragments, ice crystals (Vx)	12 D_T On small ridge, near drainage path.
12 C_T	Grass and moss hummocks 1' to 2' high and 1' to 3' in diameter, bushes 3' to 4' high.	0 - 8" ORGANIC, moss and grass 8" - 3' SILT, sandy frozen below 12" ice lenses and crystals (VrVx) 3' - 11' GRAVEL AND SAND, no visible ice (Nbn) 11' - 13' BEDROCK or boulder	12 C_T On sloping terrain, about 3 to 4 degrees.
12 B_T	Grass and moss hummocks, small bushes about 1' to 2' high. On sloping ground at edge of drainage path.	0 - 1' ORGANIC, grass and moss 1' - 2½' SILT, organic, frozen below 16", ice lenses and inclusions (VrVx) 2½' - 10' SILT, clayey, ice lenses and inclusions (VrVx) 10' - 12' GRAVEL 12' - 20' ICE, silt inclusions below 16' 20' - 29½' SILT, clayey, no visible ice (Nbn) 29½' - 31½ BEDROCK or boulder	12 B_T General slope of terrain about 5 degrees to 10 degrees. Drainage paths lines with dwarf willows. Sparse spruce trees to 15' in height.
12 E_T	Moss and grass hummocks about 2' to 3' in diameter and 1' to 2' high. Bushes about 2' to 3' high.	0 - 1' ORGANIC, grass and moss 1' - 30' SILT, clayey, frozen below 16", ice lenses and crystals (VrVx)	12 E_T On top of small knoll
12 F_T	Small grass and moss hummocks. Free water in grass	0 - 1' ORGANIC, grass and moss 1' - 20' SILT, clayey, frozen below 16" ice lenses, and crystals (VrVx)	12 F_T At edge of closed pond, in level area.
			12 G_0 Series of 6 beach ridges along contours of slope between elevation 1200' and 1300' (helicopter altimeter elevation).
			12 A_0 Rock sample identified as grey dolomite.
			Lake infilling from south
			Area apparently recently infilled
			Infill



Cross-section through B, C & D

Sketch Not To Scale



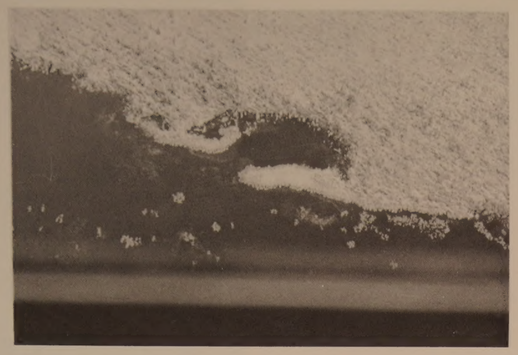
LAT. 67° 50'
LONG. 140° 35'

AVE. ALTITUDE 1400'
MEAN ANNUAL AIR TEMP. 12°F

SITE NO. 12 SHEET NO. 74
PLATE NO. 30

Picture: 1 Slate outcrop on top of knoll

Site: 12 J_0

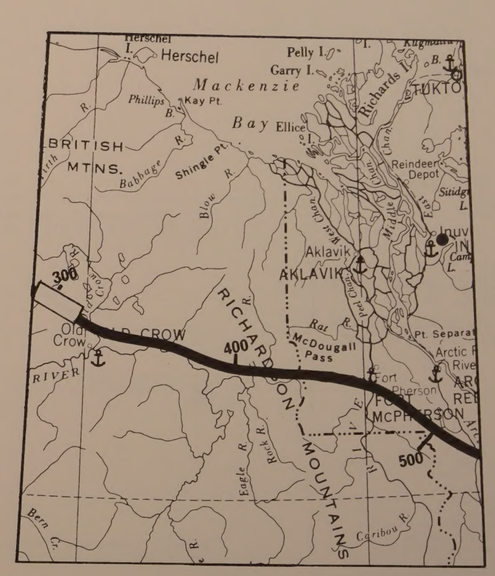


Picture: 2 Infilling lakes adjacent to Schaeffer Creek

Site: 12

Picture: 3 Infilling lakes adjacent to Schaeffer Creek

Site: 12

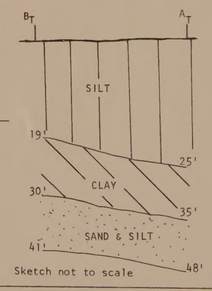


Index 2

Pictures taken in early September, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	TITLE: Photo Mosaic and Terrain Investigation MILE 296 TO MILE 318
SUBMITTED: L Jewell	DATE: Dec/70
APPROVED: Cudgeon	DATE: Dec/70
SITE No.: 12	PLATE No.: 31
SHEET No.: 74	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
SEGREGATED ICE NOT VISIBLE BY EYE				
Nf POORLY BONDED				Lake infilling at south end Lake almost infilled with grass Infilling lake with treed island
Ndn WELL BONDED – NO EXCESS ICE	13 A_T	Small mounds of grass and moss	0 - 1' ORGANIC, moss 1' - 2½' SILT, organic, frozen below 2' ice crystals and lenses (Vx,Vr) 2½' - 9' SILT, clayey, Nbn to 5', Nbe to 9' 9' - 20' CLAY, silty, ice crystals and lenses (Vx, Vr)	13 A_T At center of possible old lakebed.
Nde WELL BONDED – EXCESS ICE	13 B_T	Moss and grass cover with dwarf willow 2' to 3' high.	0 - 1' ORGANIC, grass and moss 1' - 5' SILT, organic, frozen below 2', ice lenses and crystals (Vr, Vx) 5' - 20' CLAY, silty, ice lenses (Vr)	13 B_T On small ridge beside 13 A_T. Sparse spruce trees to 12' in height.
VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK				Lake infilling with grass.
Vx INDIVIDUAL ICE INCLUSIONS	13 E_T	Grass and moss mounds. Standing water between mounds.	0 - 1' ORGANIC, grass and moss 1' - 5' SILT, organic, frozen below 14", ice lenses and crystals (Vr, Vx) 5' - 10' SILT, sandy, ice lenses and crystals (Vr, Vx) 10' - 20' SAND, fine, silty, ice crystals and lenses (Vx, Vr)	13 E_T At edge of swale in meander. Level area with patches of snow, Picture 1.
Vc ICE COATINGS ON PARTICLES	13 D_T	Moderately dense spruce to 15' in height, dwarf willow to 4', small moss hummocks about 1' in height and 3' to 4' in diameter.	0 - 1' ORGANIC, grass and moss 1' - 5' SILT, organic, frozen below 14" ice crystals and lenses (Vr,Vx) 5' - 19' SILT, sandy, ice crystals and lenses (Vr, Vx) 19' - 20' SAND, ice lenses (Vs)	13 D_T In area covered with moderately dense spruce trees 3' to 25' in height, dwarf willow, Picture 2.
Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS				Silt and sand bars in Old Crow River Lake infilling
Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS	13 F_T	Grass and moss hummocks about 1' high and 1' to 2' in diameter. Dwarf willow.	0 - 1' ORGANIC, grass and moss. 1' - 9' SILT, organic, frozen below 14", many ice lenses and inclusions (Vr, Vx) 9' - 20' SILT, minor ice lenses (Vr)	13 F_T Silt underlying muskeg; no gravel apparent. Sparse spruce trees to 10' in height. See Pictures 3 and 4. Testhole may have missed gravelly spit.
VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK				Old lake completely infilled
				13 H_0 Muskeg (frost encountered at 18")
ICE & SOIL ICE WITH SOIL INCLUSIONS				Sand and gravel deposit
				13 C_0 Pictures 5, 6, 7, & 8 show whole area in sequence of development from polygons through thaw ponds to lakes (with deep water) to infilling ponds.
ICE ICE WITHOUT SOIL INCLUSIONS				13 G_0 4" muskeg overlying silt and gravel Willow shrubs in gully
LEGEND: SOIL – ICE –	15 B_T	Grass and moss hummocks. Moderately dense spruce to 30' in height, dwarf birch and willow to 5' in height.	0 - 1' ORGANIC, grass and moss 1' - 2' SILT, organic, frozen below 14" ice lenses (Vr) 2' - 3' ICE, silt lenses 3' - 19' SILT, sandy, major ice lenses (Vr, Vx) 19' - 30' CLAY, silty, ice lenses (Vr) 30' - 36' SILT, no visible ice (Nbn) 36' - 41' SAND, fine, silty (Nbn)	15 B_T On pediment area, covered with moderately dense spruce trees 1' to 30' in height. See Pictures 9 and 10.
	15 A_T	Grass and moss hummocks with dwarf willows and birch 1' to 1½' high.	0 - 1' ORGANIC, grass and moss 1' - 2' SILT, organic, frozen below 18" 2' - 25' SILT, many ice lenses (Vr) less ice with depth, Nbn below 19' 25' - 35' CLAY, silty, no visible ice (Nbn) 35' - 48' SAND, fine, silty (Nbn)	15 A_T On pediment area, sparse spruce trees 2' to 5' in height. See Pictures 11 and 12. Pediment probably covered by lacustrine or eolian silt.
	15 C_T	Grass and standing water, some moss under grass.	0 - 1' ORGANIC, grass and moss 1' - 2' SILT, organic 2' - 9' SILT, frozen below 3', ice lenses and inclusions (Vr, Vx) less ice with depth. 9' - 20' CLAY, with organic silt, ice lenses.	15 C_T In poorly drained area with thaw ponds infilled with grass. See Pictures 13 & 14.
				Ice-wedge polygon area.



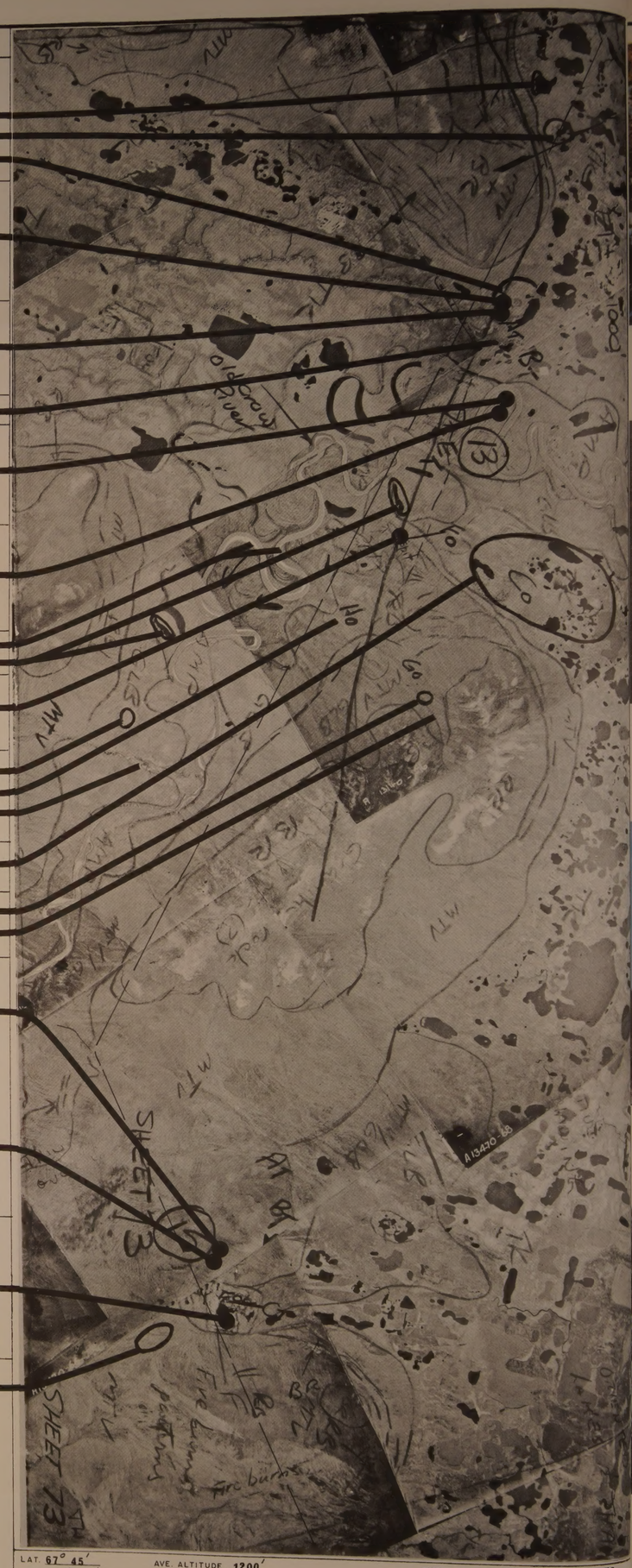
Sketch not to scale

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
RB	Raised beach ridges, spits and strand lines; gravelly to bouldery
MTV	Smooth streaked slopes in foothill localities; mainly thick ice-rich organic silt (loessial) with minor sand and gravel inclusions on extensive, flatter lower slopes to thin colluvial or residual bouldery to gravelly silt over bedrock below base of bedrock slopes, with stratigraphy often inferrable from local geomorphic setting
AMP	Actively meandering flood plain; mainly ice-rich silt and fine sand
GLB	Thick glacial-like materials; mainly ice-rich silt and fine sand with minor clay
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand

SEE PLATE No 3 for a comprehensive description of symbols.



LAT. 67° 45'
LONG 139° 50'
AVE. ALTITUDE 1200'
MEAN ANNUAL AIR TEMP. 13°F

SITE NO 13 & 15 SHEET NO. 73
PLATE NO. 32

Picture: 1 Close up of drill hole site.

Site: 13 E_T

Picture: 2 General view drill hole area. Spruce and dwarf willow.

Site: 13 D_T

Picture: 3 Drill rig on site. Hummocky ground.

Site: 13 F_T

Picture: 4 Close-up of vegetation, grass hummocks, dwarf birch and willow.

Site: 13 F_T

Picture: 5 Polygonal pattern, thermokarst terrain, developing ponds.

Site: 13 C_o

Picture: 6 Thermokarst terrain, expanding ponds.

Site: 13 C_o

Picture: 7 Thermokarst terrain, large ponds.

Site: 13 C_o

Picture: 8 Thermokarst terrain, infilling pond.

Site: 13 C_o

Picture: 9 General view at drill hole in light spruce.

Site: 15 B_T

Picture: 10 Close-up of vegetation at drill hole, hummocks, dwarf birch and willow.

Site: 15 B_T

Picture: 11 General view drill hole area. Sparse spruce, hummocky ground.

Site: 15 A_T

Picture: 12 Close-up of vegetation at drill hole. Dwarf willow and birch, grassy hummocks.

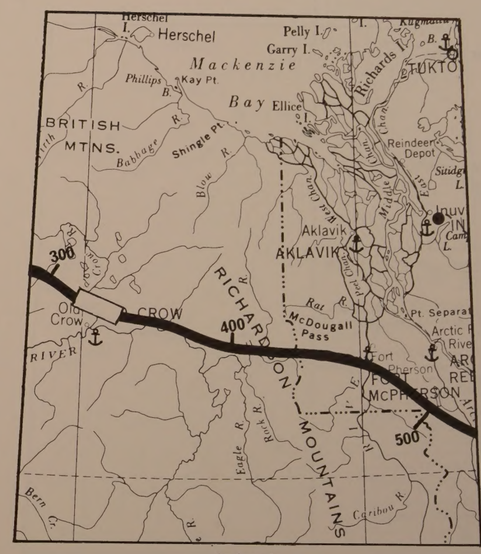
Site: 15 A_T

Picture: 13 Drill rig on site. Thaw pond in background.

Site: 15 C_T

Picture: 14 Close-up of vegetation at drill hole showing grass and standing water.

Site: 15 C_T



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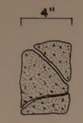
Pictures taken in early September, 1970.

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE	
	TITLE: Photo Mosaic and Terrain Investigation MILE 316 TO MILE 342	
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: L. Jewell DATE: Dec/70 SITE No.: 13 & 15 PLATE No.: 33	
	APPROVED: Eur Speer DATE: Dec/70 SHEET No.: 73	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions
MTV	Smooth streaked slopes in foothill localities, mainly thick ice-rich organic silt (leossial) with minor sand and gravel inclusions on extensive, flatter lower slopes to thin colluvial or residual bouldery or gravelly silt over bedrock below base of bedrock slopes, with stratigraphy often inferrable from local geomorphic setting
AFD	Variable-textured alluvial fans; mainly thin silt over sand and gravel with major textural variations often inferrable from local geomorphic (depositional) setting
GLB	Thick glacial-like materials; mainly ice-rich silt and fine sand with minor clay
HT	High terrace; predominantly ice-rich silt with some pebbles and minor gravel and sand inclusions
AMP	Actively meandering flood plain; mainly ice-rich silt and fine sand
MK	Muskeg, swamp, marsh, bog; includes all unpatterned peatlands
AMX	Alpine moraine complex; mainly bouldery coarse till associated with multiple glaciations of Brooks Range

SEE PLATE No 3 for a comprehensive description of symbols.

Large delta from tributary stream.

Cliff as at 14 B_0

Sand, some gravel

Sand and gravel

Sand and gravel, some silt
Old meander channel, Picture 4.

14 C_o Active point bar shown on Picture 1. Large deposit of mainly gravel, Picture 2, and some sand, Picture 3.

14 B_0 Mainly silty with sand and gravel pebbles exposed in river bank, Picture 5. Probably silt terrace.

Gravel

Gravel and sand

Sand

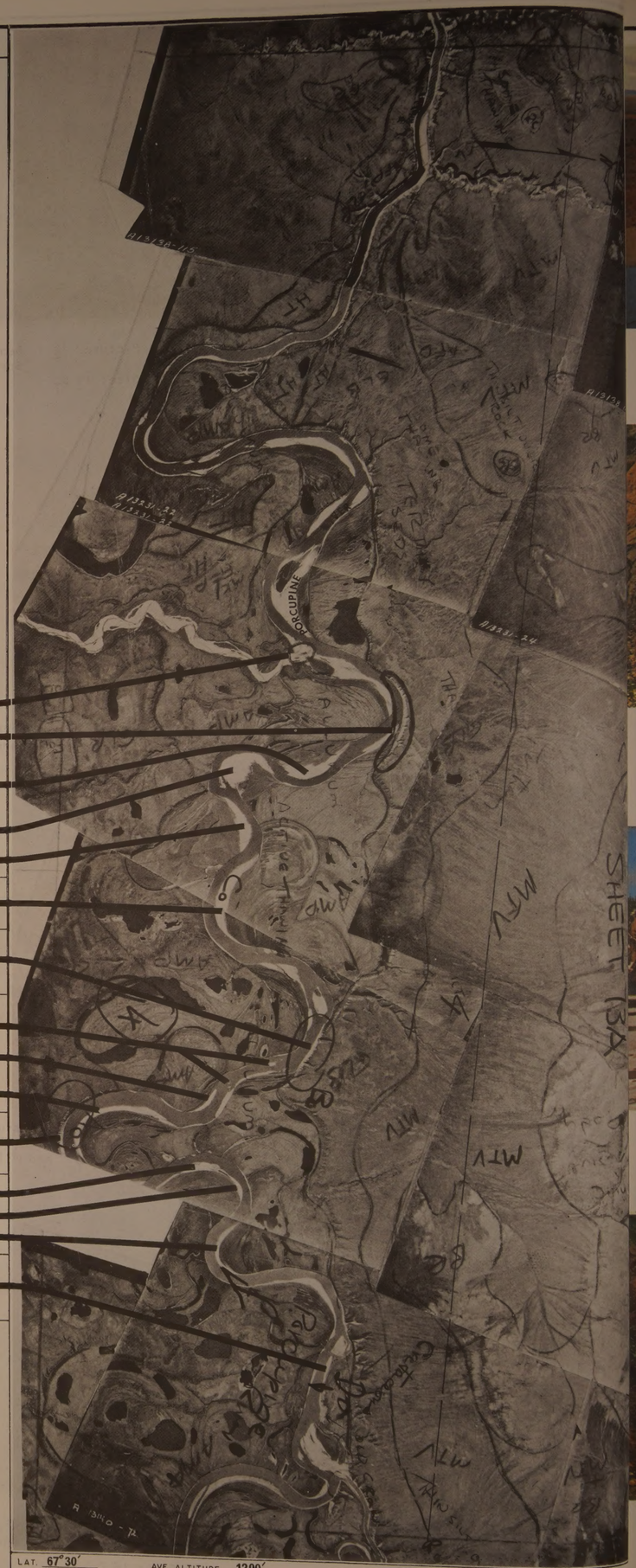
14 A_o Sand and gravel point bar on north bank of river. Sand toward bank grading to gravel at water edge, Pictures 6 & 7. Pictures 8 & 9 show 85' high cliff on the south bank, consisting of 20' of sandstone overlying shale.

Sand grading to gravel at water edge.

Sand

Sand and gravel

14 D_0 River bank at Old Crow. River is cutting back into old FFP which consists basically of layered silt overlying gravel and sand. The bank is about 25' in height, the top 20' is silt, Picture 10. Sands and gravels are mainly sandstone, and conglomerate, Picture 11.



LAT. 67°30′
LONG 140°00′

AVE. ALTITUDE 1200′
MEAN ANNUAL AIR TEMP. 13°F

SITE NO 14 SHEET NO. 73 A
PLATE NO. 34

Picture: 1 Aerial view of point bar in Porcupine River

Site 14 C_o

Picture: 2 Gravel on point bar

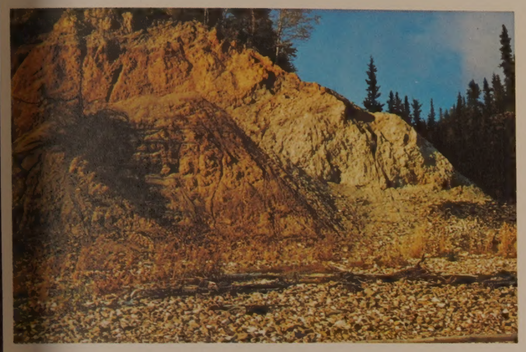
Site 14 C_o

Picture: 3 Sand on point bar

Site 14 C_o

Picture: 4 Unusual channel remains of Porcupine River

Site 14 C_o

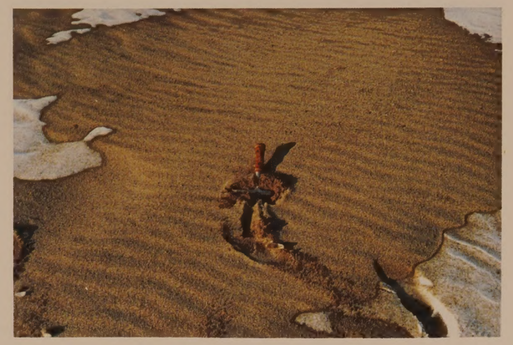


Picture: 5 Silty sand and gravel exposure and erosion channel cut in bank

Site 14 B_o

Picture: 6 Gravel close to water

Site 14 B_o



Picture: 7 Coarse to medium sand (clean) close to bank.

Site: 14 A_0

Picture: 8 Showing cliff across river from point bar

Site 14 A_o

Picture: 9

Close-up of cliff shown in Picture 8.

Site: 14 A_0

Picture: 10 View of river bank from gravel beach at Old Crow

Site: 14 D_0

Picture: 11 Sand and gravel on the river bank

Site 14 D_o

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Pictures taken in early September, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 300 TO MILE 330 Offset

SUBMITTED	DATE	SITE No.	PLATE No.
K Jewell	Dec/70	14	35
APPROVED	DATE	SHEET No.	
Ewspier	Dec/70	73 A	

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED – NO EXCESS ICE

Nbe WELL BONDED – EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL – ICE –

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by–

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
MTV	Smooth streaked slopes in foothill localities; mainly thick ice-rich organic silt (loessial) with minor sand and gravel inclusions on extensive, flatter lower slopes to thin colluvial or residual bouldery to gravelly silt over bedrock below base of bedrock slopes, with stratigraphy often inferrable from local geomorphic setting
GLB	Thick glacial-lake materials; mainly ice-rich silt and fine sand with minor clay
AMP	Actively meandering flood plain; mainly ice-rich silt and fine sand
RB	Raised beach ridges, spits and strand lines; gravelly to bouldery
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions
FOL	Filled former oriented lakes; mainly thin ice-rich peat and organic silt over sand and gravel or till
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel
HT	High terrace; predominantly ice-rich silt with some pebbles and minor gravel and sand inclusions
OSF	Old slide features; mainly weak stratified (sand over silt and clay) glacial-lake deposits or bentonitic clay shales
SP	Speckled pattern of small ponds on undulating to rolling plain; mainly thin to thick ice-rich loessial silt over till or bedrock or sand and gravel
CAF	Coalescing alluvial fans and slopewash deposits; mainly ice-rich organic and inorganic silt and fine sand with minor pebbles locally

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE
16 C_T	Burnt trees, thin moss cover with exposed cobbles and boulders. Spruce trees, 1' to 5' in height, occasional dwarf birch and willow to 4' in height.	0 - 2" ORGANIC, moss 2" - 10' SILT, rock and gravel, locally organic, unfrozen 10' - 48' SAND, silty, pebbles, shale like, unfrozen
16 D_T	Dwarf willow, moss, lichen	0 - 6" ORGANIC, moss and lichen 6" - 10' SILT, organic, angular gravel, unfrozen 10' - 21' CLAY, silty, slightly organic, broken sandstone and shale, unfrozen.

RECONNAISSANCE OBSERVATION NOTES

Fire burns

Treed pediment slopes

Thaw ponds

Lakes infilling with grass

Active thermokarst lake formation

Lake infilling with grass

Fire burns

Ice-wedge polygons

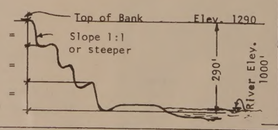
Lake infilled with grass

16 A_O Slide on north bank of Porcupine River. The slide consists of at least 4 blocks as shown by the sketch below. Pictures 1 & 2, and 3 are aerial views.

Picture 4 looking at slide along river

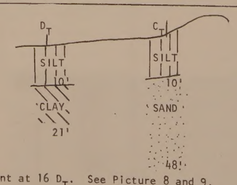
Picture 5 shows successive thrusts

Samples: fine-grained grey sandstone.



Fireburns

16 C_T Near top of pediment. Surface littered with angular pieces of fine-grained thinly-bedded sandstone. Burnt area. See Pictures 6 and 7.



16 D_T Near bottom of pediment, slightly sloping ground. Dense cover of dwarf willow, spruce to 4' high. Burnt trees appear to be spruce.

Rocks noted on ground surface at 16 C_T absent at 16 D_T. See Picture 8 and 9.

Sand and gravel bars

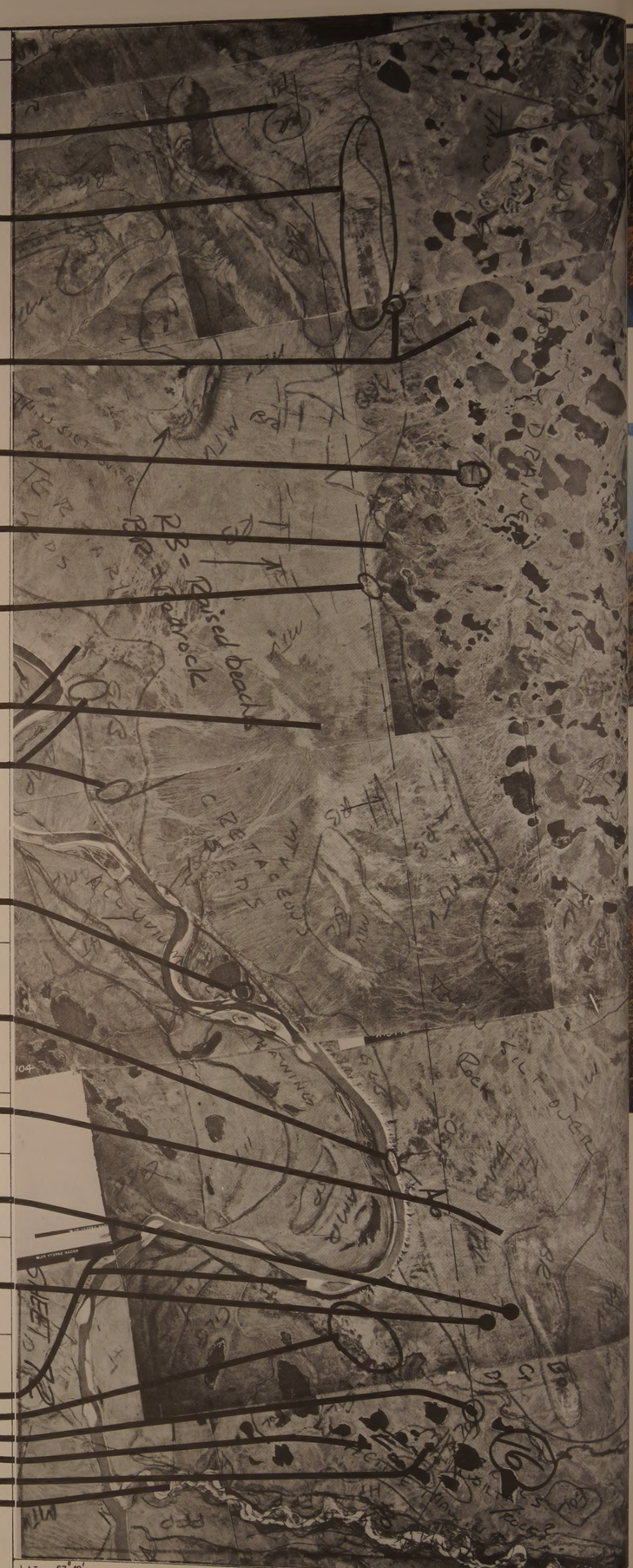
FFP (old meanders)

Infilled lake

Grass infilling ponds

Infilling of ponds

Sand and gravel bar (very large deposit)



LAT. 67° 40'
LONG. 139° 00'

AVE. ALTITUDE 1300'

MEAN ANNUAL AIR TEMP. 13 ° F

SITE NO. 16 SHEET NO. 72
PLATE NO. 36

Picture: 1 Aerial view of slide on north bank of Porcupine River.

Site: 16 A_0

Picture: 2 Aerial view of slide on north bank of Porcupine River.

Site: 16 A_0

Picture: 3 Aerial view of slide on north bank of river. Note block slumping on right.

Site: 16 A_0

Picture: 4 Looking at slide along river.

Site: 16 A_0

Picture: 5 Successive thrusts in slide.

Site: 16 A_0

Picture: 6 General view of Site 16 C_T

Site: 16 C_T

Picture: 7 Close-up of ground surface at drill hole.

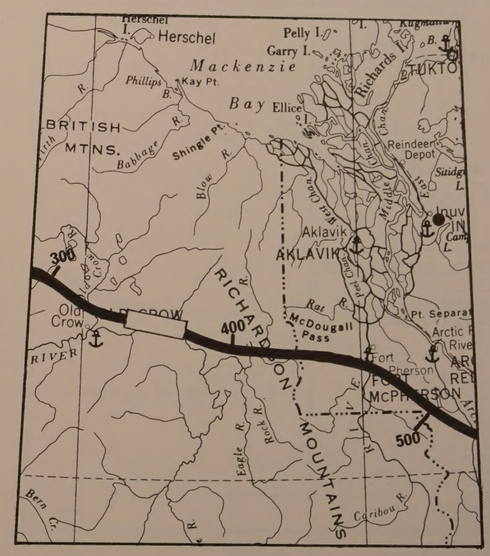
Site: 16 C_T

Picture: 8 General view of Site 16 D_T

Site: 16 D_T

Picture: 9 Close-up of vegetation at drill hole.

Site: 16 D_T



Index 2

Pictures taken in early September, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE			
	TITLE: Photo Mosaic and Terrain Investigation MILE 342 TO MILE 368			
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: L Jewell	DATE: Dec/70	SITE No.: 16	PLATE No.: 37
	APPROVED: Ev Lyser	DATE: Dec/70	SHEET No.: 72	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
SEGREGATED ICE NOT VISIBLE BY EYE				
Nf — POORLY BONDED				Active flood plain covered with gravel.
Nbn — WELL BONDED – NO EXCESS ICE				Lake infilled with grass and trees Infilling lake Ice-wedge polygons Lake infilled by grass and with tree islands Lake infilling with grass islands Ice-wedge polygons Infilling lake Gravel deposits at bends in creek Grass infilling lakes Fire burns Ice-wedge polygons Grass infilling lakes
VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK				
Vx — INDIVIDUAL ICE INCLUSIONS				
Vc — ICE COATINGS ON PARTICLES				
Vr — RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS				
Vs — STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS				
VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK				
ICE & SOIL — ICE WITH SOIL INCLUSIONS				
ICE — ICE WITHOUT SOIL INCLUSIONS				
LEGEND: SOIL – ICE –				
	17 F_O			Flood plain and bank of Porcupine River at Site 17 as shown on Picture 1. The bank is gently sloping from about 10' to 15' height above river level. It consists of silt, minor gravel over siltstone. Bank is degrading.
				Rock outcrop.
	17 C_T	Moss and grass tussocks, small spruce 1' to 5' with blueberry, dwarf willow and birch.	0 – 6" ORGANIC, moss and grass 6" – 5' SILT, organic, frozen below 18", ice lenses (Vr) 5' – 12' SILT, clayey, ice lenses and inclusions (Vr, Vx) 12' – 19' GRAVEL, sandy 19' – 20' BOULDER or BEDROCK	17 C_T On high terrace. Picture 2 shows vegetation at drill hole.
				Wet swampy terrain, grass clumps. Clumps of black spruce much higher than surrounding trees Infilling lakes
	17 B_O			Immediately below tree line. Grass clumps, blueberry bushes, and willows. Standing water between grass clumps, Picture 3. Organic silt, frozen below 2'.
	17 A_O			Top of rock outcrop. Conglomerate and fine-grained sandstone. See Picture 4.
	17 E_O			Top of rock outcrop Conglomerate and medium-grained grey sandstone, Picture 5.
				Heavy tree growth, black spruce Lakes with grass infill at edges, some grass islands. Thaw lakes Sand, silt and gravel bars in river
	18 A_O			On top of ridge Sandstone and conglomerate, lightly weathered, Picture 6.
				Ice-wedge polygons thawing Lakes infilling with grass.
	18 C_T	Grass and moss hummocks, very sparse willow.	0 – 1' ORGANIC, grass and moss 1' – 2' SILT, organic, frozen at 18" 2' – 13' SILT, clayey, ice lenses and inclusions (Vr, Vx) 13' – 14' GRAVEL 14' – 15' SILT 15' – 23' ICE, minor silt inclusions 23' – 26' SHALE	18 C_T On high terrace. Picture 7 shows grass clumps cover at drill hole. The valley to the east of the site has exposed horizontally stratified sedimentary rocks almost to the surface.
	18 B_T	Heavy spruce to 25' in height, occasional birch, poplar. Moss hummocks about 3' to 4' in diameter and 1' high, grass.	0 – 1' ORGANIC, moss frozen below 8" 1' – 8' SILT, clayey, ice lenses and inclusions (Vr, Vx) 8' – 11' ICE 11' – 18' SILT, clayey, ice lenses and inclusions (Vr, Vx), less ice with depth. 18' – 30' CLAY, shale particles, ice crystals (Vx)	18 B_T In area covered with heavy black spruce with occasional poplar and birch see Picture 8. Picture 9 shows vegetation at the drill hole site.
				Rock exposure

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—
J. D. Mollard and Associates Limited

MAP SYMBOL — ABBREVIATED DESCRIPTION OF TERRAIN

MTV - Smooth streaked slopes in foothill localities; mainly thick ice-rich organic silt (loessial) with minor sand and gravel inclusions on extensive, flatter lower slopes to thin colluvial or residual bouldery to gravelly silt over bedrock below base of bedrock slopes, with stratigraphy often inferrable from local geomorphic setting

GLB - Thick glacial-lake materials; mainly ice-rich silt and fine sand with minor clay

RB - Raised beach ridges, spits and strand lines; gravelly to bouldery

FFP - "Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel

MK - Muskeg, swamp, marsh, bog; includes all unpatterned peatlands

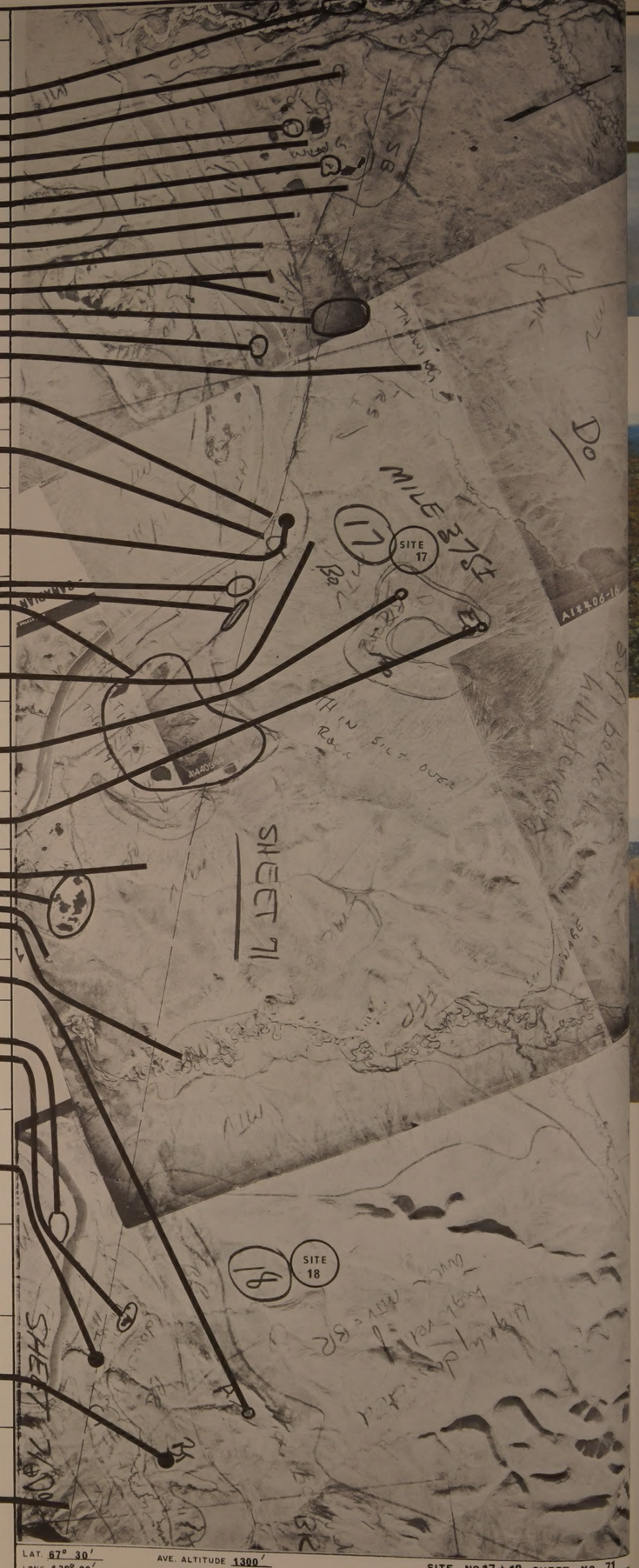
TK - Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic water-laid silt and fine sand

SB - String bog (ribbed fen); includes all unpatterned deposits

SEE PLATE No 3 for a comprehensive description of symbols.

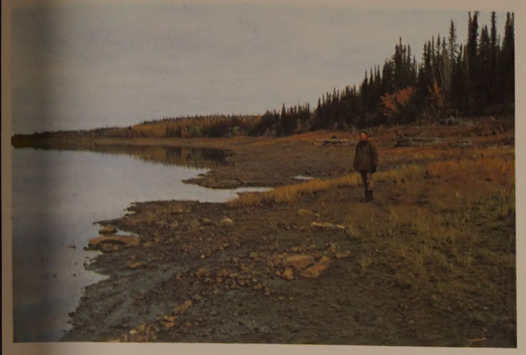
NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "



LAT. 67° 30'
LONG. 138° 00'
AVE. ALTITUDE 1300'
MEAN ANNUAL AIR TEMP. 14°F

SITE NO. 17 & 18 SHEET NO. 71
PLATE NO. 38



Picture: 1 Bank of Porcupine River.

Site: 17 F_0

Picture: 2 Close-up of vegetation at drill hole. Spruce, grass clumps, dwarf willow and blueberry

Site: 17 C_T

Picture: 3 Close-up of vegetation. Grass clumps, blueberry, dwarf willow.

Picture: 4 Rock outcrop
Conglomerate and sandstone.

Site: 17 A_0

Picture: 5 Rock outcrop
Conglomerate and sandstone.

Site: 17 E_0

Picture: 6 Top of ridge. Rock outcrop is conglomerate and sandstone.

Site: 18 A_0

Picture: 7 Close-up of vegetation at drill hole. Grassy hummocks.

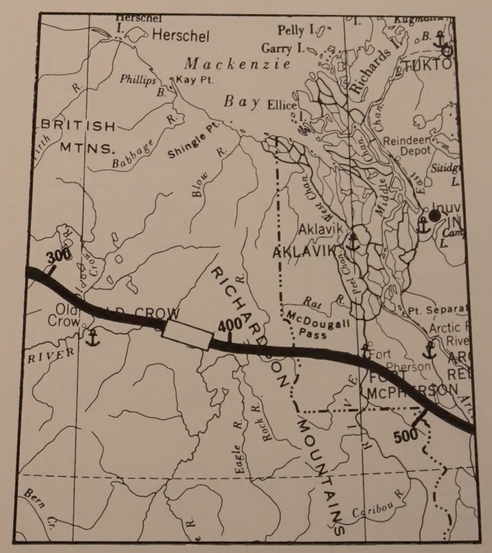
Site: 18 C_T

Picture: 8 Aerial view of site in heavy spruce, occasional birch, poplar.

Site: 18 B_T

Picture: 9 View across site.

Site: 18 B_T



Index 2

Pictures taken in early September, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

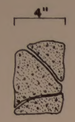
PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 368 TO MILE 391

SUBMITTED	DATE	SITE No.	PLATE No.
R Jewell	Dec/70	17&18	39
APPROVED	DATE	SHEET No.	
Lindgren	Dec/70	71	

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

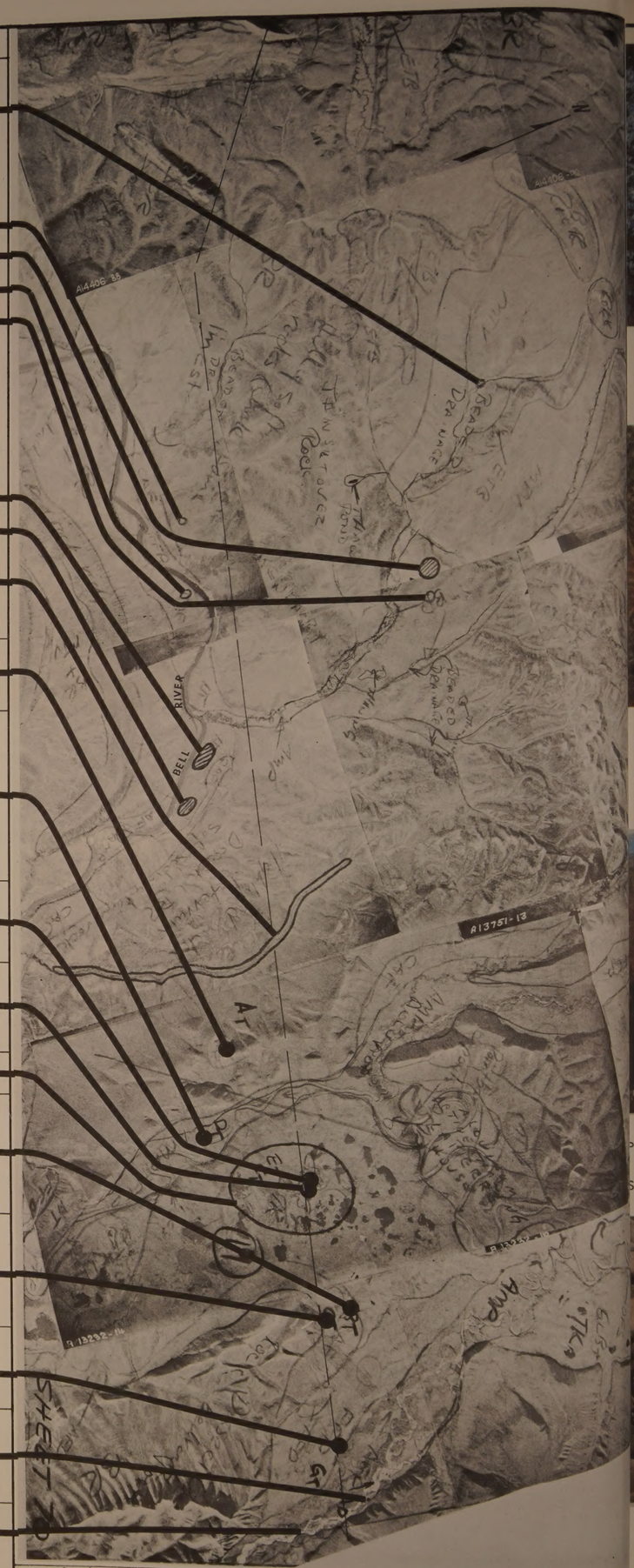
J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions
CAF	Coalescing alluvial fans and slopewash deposits; mainly ice-rich organic and inorganic silt and fine sand with minor pebbles locally
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel
MTV	Smooth streaked slopes in foothill localities; mainly thick ice-rich organic silt (loessial) with minor sand and gravel inclusions on extensive flatter lower slopes to thin colluvial or residual bouldery to gravelly silt over bedrock below base of bedrock slopes, with stratigraphy often inferrable from local geomorphic setting
ETB	Steep, eroding thaw banks; includes banks containing silt, sand, gravel, till or bedrock
AMP	Actively meandering flood plain; mainly ice-rich silt and fine sand
HT	High terrace; predominantly ice-rich silt with some pebbles and minor gravel and sand inclusions.
BD	Beaded drainage
GLB	Thick glacial-lake materials; mainly ice-rich silt and fine sand with minor clay
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand
OSF	Old slide features; mainly weak stratified (sand over silt and clay) glacial-lake deposits or bentonitic clay shales
AFD	Variable-textured alluvial fans; mainly thin silt over sand and gravel with major textural variations often inferrable from local geomorphic (depositional) setting

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
			Thaw pond
			Thaw pond
			Ponds developing from IWP
			Thaw pond
			Poorly drained area. Thaw ponds grass infilling.
			Thaw area. Ponds forming from IWP.
			Thaw area. Ponds forming from IWP
			Beaded drainage. No sand or gravel evident in stream bed.
19 A_T	Dwarf birch to 6' in height; moss and lichen.	0 - 5' GRAVEL, and SHALE, dark grey 5' - 10' SHALE, weathered black.	19 A_T Drill hole site on crest of ridge. Picture 1 of a test pit adjacent to the drill hole location shows the profile of moss and organic material overlying shale bedrock.
19 D_T	Light spruce and tamarack 2' to 15' in height, labrador tea, blueberry grass and moss hummocks to 1' in height; lichen.	0 - 1' ORGANIC 1' - 2' SILT, organic, frozen at 1' ice crystals (Vx) 2' - 3' SILT, ice crystals and lenses (Vx, Vr) 3' - 17' ICE 17' - 27' SILT, sandy, ice crystals and lenses (Vx, Vr) 27' - 46' ICE, silt inclusions 46' - 49' CLAY, silty, ice lenses and crystals (Vx, Vr)	19 D_T On inactive meander flood plain. Drill hole located on relatively level area 40' above present river elevation. Picture 2 shows area looking towards higher ground away from river. Picture 3 is a close-up view of the site vegetation.
19 F_T	Sparse spruce to 10' in height, grass hummocks to 2' in diam., 1½' high, labrador tea, lichen and moss.	0 - 1' ORGANIC 1' - 2' SILT, organic, frozen at 1½' ice lenses (Vr) 2' - 21' SILT, clayey, ice lenses and inclusions (Vx, Vr)	19 F_T On higher ground in thermokarst area. Picture 4 from test hole location overlooks site 19 E_T which is 50 yds. east and 15 ft. lower than this hole. Picture 5 is a close-up view of the site vegetation.
19 E_T	Sparse spruce to 15' in height, dwarf birch to 3' in height, grass and moss hummocks 1' to 2' diam., and 1' to 1½' in height, labrador tea, lichen.	0 - 10" ORGANIC 10" - 2' SILT, organic, frozen at 18" 2' - 20' SILT, considerable ice (VxVr) to 15', then no visible ice Nbn 20' - 21' CLAY, silty, ice lenses (Vs)	19 E_T In low swampy ground in thermokarst area. Picture 6 looking east toward Richardson Mountains shows general area including adjacent grass infilling thaw pond. Picture 7 is a close-up view of the site vegetation.
			Thermokarst Lakes infilling with grass.
19 B_T	Grass and moss hummocks 1' to 2' diam. 1' to 2' high, dwarf birch and willow to 6' in height, lichen.	0 - 1' ORGANIC 1' - 2' SILT, organic, frozen at 1', ice lenses (Vr) 2' - 14' ICE, silt inclusions 14' - 21' SILT, sand lenses, no visible ice Nbn 21' - 28' ICE, silt lenses 28' - 30' SHALE	19 B_T Test site on alluvial fan. Ground surface slopes down at approximately 3° to the north as shown in Picture 8.
19 C_T	Grass and moss hummocks 1' to 2' diam., 1' high, dwarf birch to 2' high, labrador tea.	0 - 1' ORGANIC 1' - 2' SILT, organic, frozen at 1½'. ice crystals (Vx) 2' - 9' SILT, low plastic, ice crystals and lenses (Vr, Vx) 9' - 24' ICE 24' - 28' SILT, ice lenses (Vr) 28' - 30' BOULDER or BEDROCK	19 C_T Test site on alluvial fan approximately 400 yds. south of 19 B_T and towards higher ground. Surface slope is approximately 6° as shown on Picture 9 which looks down towards Site 19 B_T. Picture 10 is a close-up view of the site vegetation.
19 G_T	Grass hummocks 1' to 2' in diam. up to 1½' in height, lichen and moss, labrador tea.	0 - 1' ORGANIC 1' - 4' SILT, frozen at 1½', ice lenses and crystals (Vx, Vr) 4' - 7' GRAVEL, sandy 7' - 11' BOULDER or BEDROCK	19 G_T On extensive, relatively level inactive flood plain. Picture 11 shows location of drill hole and proximity of 15' to 25' high black spruce marking edge of active flood plain.
			19 H_0 Active flood plain. River channel is braided, subject to flash flooding, and covered with gravel and cobbles identified as greywacke sandstone, laminated black limestone and black slate, as shown in Picture 12. Adjacent to the flood plain are near vertical cliffs of actively weathering shale, approximately 70 ft. in height, shown in Pictures: 13 and 14.
			Coarse aggregate in stream bed.

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "



LAT. 67° 25'
LONG. 137° 15'

AVE. ALTITUDE 1500'
MEAN ANNUAL AIR TEMP. 15°F

SITE NO. 19 SHEET NO. 70
PLATE NO. 40

Picture: 1 Hand excavation at top of ridge. 2" moss over shale. Light snow cover.
Site: Near 19 A_T

Picture: 2 Looking across site to higher ground covered with spruce and tamarack trees.
Site: 19 D_T

Picture: 3 Close-up of vegetation at drill hole.
Site: 19 D_T

Picture: 4 Looking towards 19 E_T and Richardson Mountains.
Site: 19 F_T

Picture: 5 Close-up of vegetation at drill hole.
Site: 19 F_T

Picture: 6 Looking east across drill hole site, low swamp ground, to Richardson Mountains.
Site: 19 E_T

Picture: 7 Close-up of vegetation at drill hole.
Site: 19 E_T

Picture: 8 Looking north from drill hole.
Site: 19 B_T

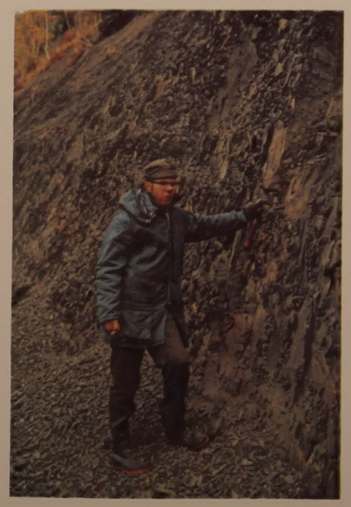
Picture: 9 Looking north towards 19 B_T from 19 C_T

Picture: 10 Close-up of vegetation at drill hole.
Site: 19 C_T

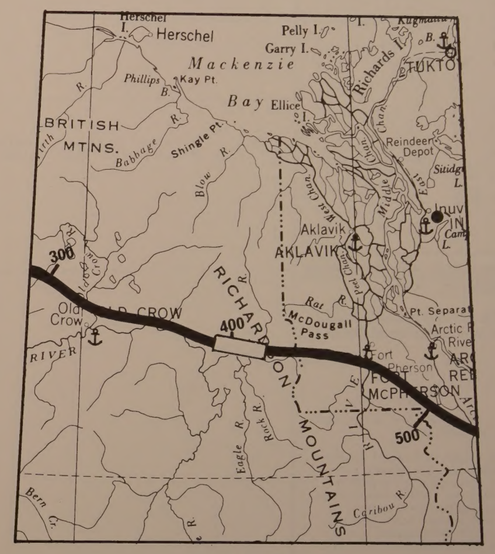
Picture: 11 Looking west from drill hole site.
Site: 19 H_0

Picture: 12 Active flood plain gravels.
Site: 19 H_0

Picture: 13 Shale cliff rising from active flood plain.
Site: 19 H_0



Picture: 14 Close-up of weathered shale cliff.
Site: 19 H_0



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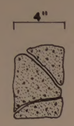
Pictures taken in late September, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE		
	TITLE: Photo Mosaic and Terrain Investigation MILE 391 TO MILE 417		
	SUBMITTED: R Jewell	DATE: Dec 70	SITE No. 19
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	APPROVED: Carl Speer	DATE: Dec 70	SHEET No. 70
			PLATE No. 41

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

Ndn WELL BONDED — NO EXCESS ICE

Nde WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ▒ ICE- □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel
MTV	Smooth streaked slopes in foothill localities; mainly thick ice-rich organic silts (loessial) with minor sand and gravel inclusions on extensive, flatter lower slopes to thin colluvial or residual bouldery to gravelly silt over bedrock below base of bedrock slopes, with stratigraphy often inferrable from local geomorphic setting
AFP	Active flood plain; mainly exposed sand, gravel and cobbles with boulders locally
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions
LST	Solifluction on sheets and lobes; mainly thin silt over bedrock
CAF	Coalescing alluvial fans and slopewash deposits; mainly ice-rich organic and inorganic silt and fine sand with minor pebbles locally
GLB	Thick glacial-lake materials; mainly ice-rich silt and fine sand with minor clay
IWP	Ice-wedge polygons; mainly developed in ice-rich silty deposits

SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE
20 D_T	Dwarf willow, birch to 5' in height grass hummocks.	0 - 1' ORGANIC 1' - 5' SAND & GRAVEL, silty, frozen no visible ice, Nbe 5' - 10' SHALE, weathered.
20 C_T	Grass and moss cover	0 - 8" ORGANIC 8" - 3' SILT, frozen, ice lenses (Vr)
20 E_T	Sparse dwarf birch to 3' in height grass hummocks 1' diam., 1' high.	0 - 8" ORGANIC 8" - 13' SILT, weathered shale fragments from 5', frozen at 1', ice lenses and crystals (Vr, Vx) 13' - 19' ICE 19' - 21' CLAY, shale like 21' - 24' ICE 24' - 25' CLAY 25' - 27' ICE, clay inclusions 27' - 30' SHALE

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

RECONNAISSANCE OBSERVATION NOTES

Trees on southern slope

20 G_0 Coarse gravel and boulder deposits identified as: 1. medium and fine-grained greywacke sandstone. 2. Thinly laminated limestone. 3. Black slate.

Picture 1 is a view looking north across the Rat River.

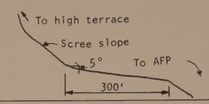
Picture 2 shows the braided river flood plain of the Rat River.

Ice wedge polygons.

Densely timbered flood plain-- poplars 10' to 15'

20 F_0 The entire sheetwash slope from crest of mountain to terrace above the Rat River is covered with angular talus. Picture 3 shows the area looking up slope and Pictures 4 and 5 show the profile of the slope. Picture 6 is a closer view of the sandstone and conglomerate towards the toe of the slope.

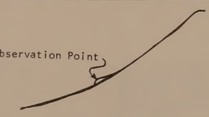
20 D_T Drill hole located on a river terrace remnant between the present river level and the high terrace. Picture 7 shows the 5° slope on the terrace and also its proximity to the active flood plain.



20 C_T Test hole in high terrace. Picture 8 looks south from the river and shows the terrace with the sandstone bedrock exposed in the cliff. Picture 9 is a close-up of the exposed bedrock at the edge of the terrace. Sample identified as argillaceous siltstone.

20 B_0 Active flood plain. Actively degrading river has large quantities of gravel and cobbles deposited in stream bed. Picture 10 shows typical deposit of material identified as:
1. Coarse-grained sandstone
2. Medium-grained sandstone
3. Quartzose siltstone
4. Medium-grained quartzose sandstone
5. Medium-grained greywacke sandstone.

20 A_0 Lobate solifluction terraces on steep slope. Picture 11 shows rock on tongue of lobate feature. Overall slope at point approximately 20°. These features are numerous along this particular slope. Rock identified as fine-grained greywacke sandstone.

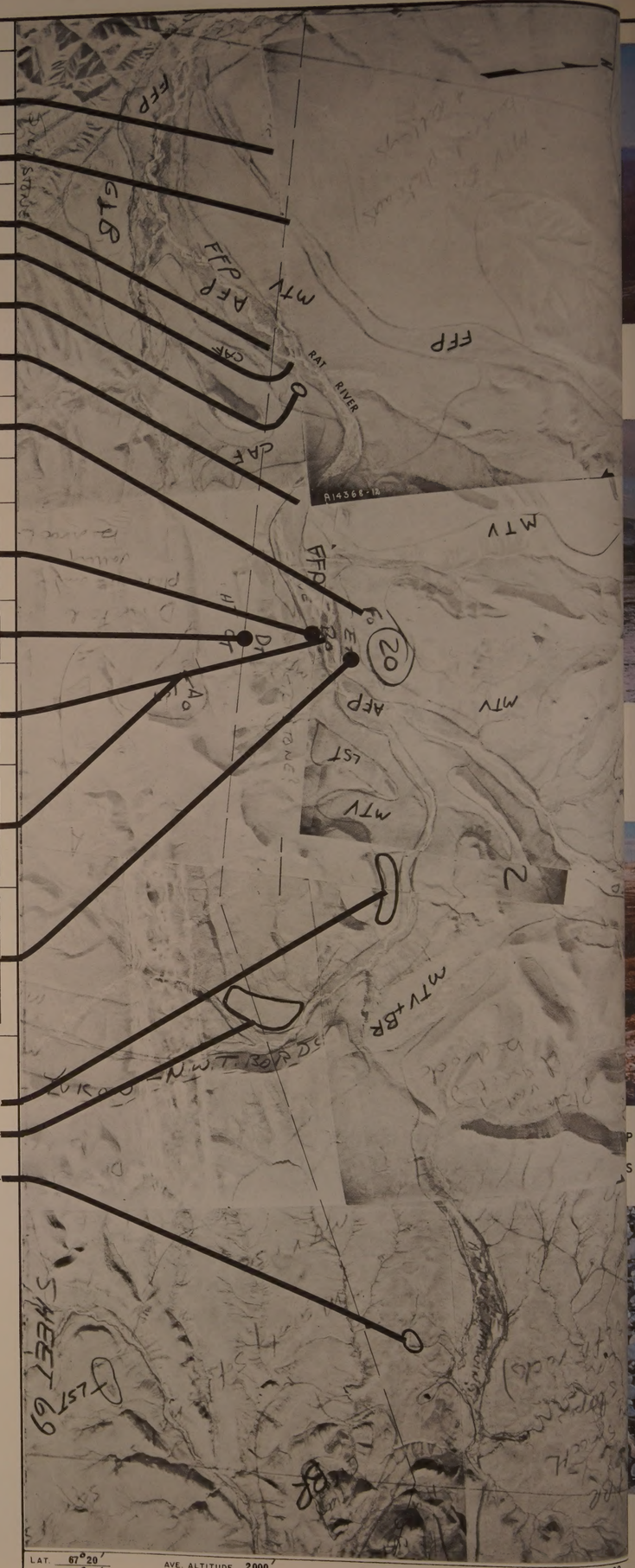


20 E_T Test hole on sheetwash slope of alluvial fan on north side of river. Picture 3 shows the site location and its relationship to the pediment and bedrock mountain slopes to the north.

Lobate solifluction features

"Fossil" flood plain.

Ice wedge polygons.



LAT. 67°20'
LONG. 136°15'
AVE. ALTITUDE 2000'
MEAN ANNUAL AIR TEMP. 16°F

SITE NO. 20 SHEET NO. 69
PLATE NO. 42

Picture: 1 Rat River valley west of Site 20

Site: between 19 & 20

Picture: 2 Rat River valley west of Site 20

Site: between 19 & 20

Picture: 3 Looking north across site.

Site: 20 E_T

Picture: 4 Looking west at pediment slope.

Site: 20 F_o

Picture; 5 Looking west across pediment and scree slope.

Site: 20 F_o

Picture: 6 Close-up of rock on pediment slope.

Site: 20 F_o

Picture: 7 From drill site looking across terrace slope to flood plain below.

Site: 20 D_T

Picture: 8 Looking south towards 20 C_T on high terrace. Note bedrock outcropping.

Site: 20 C_T

Picture: 9 Close-up of bedrock at edge of high terrace.

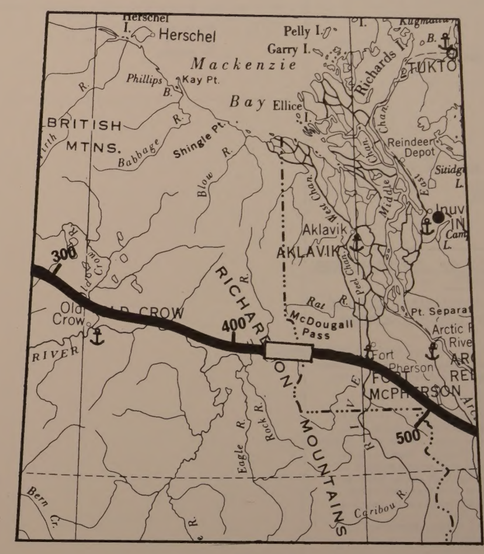
Site: 20 C_T

Picture: 10 Gravel and cobbles on active flood plain.

Site: 20 B_o

Picture: 11 Close-up looking at tongue of lobate solifluction terrace.

Site: 20 A_o



Index 2

Pictures taken in late September, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE			
	TITLE: Photo Mosaic and Terrain Investigation MILE 418 TO MILE 442			
	SUBMITTED: R Jewell	DATE: Dec/70	SITE No.: 20	PLATE No.: 43
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	APPROVED: Cudgeon	DATE: Dec/70	SHEET No.: 69	

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

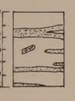
Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ▨ ICE- □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

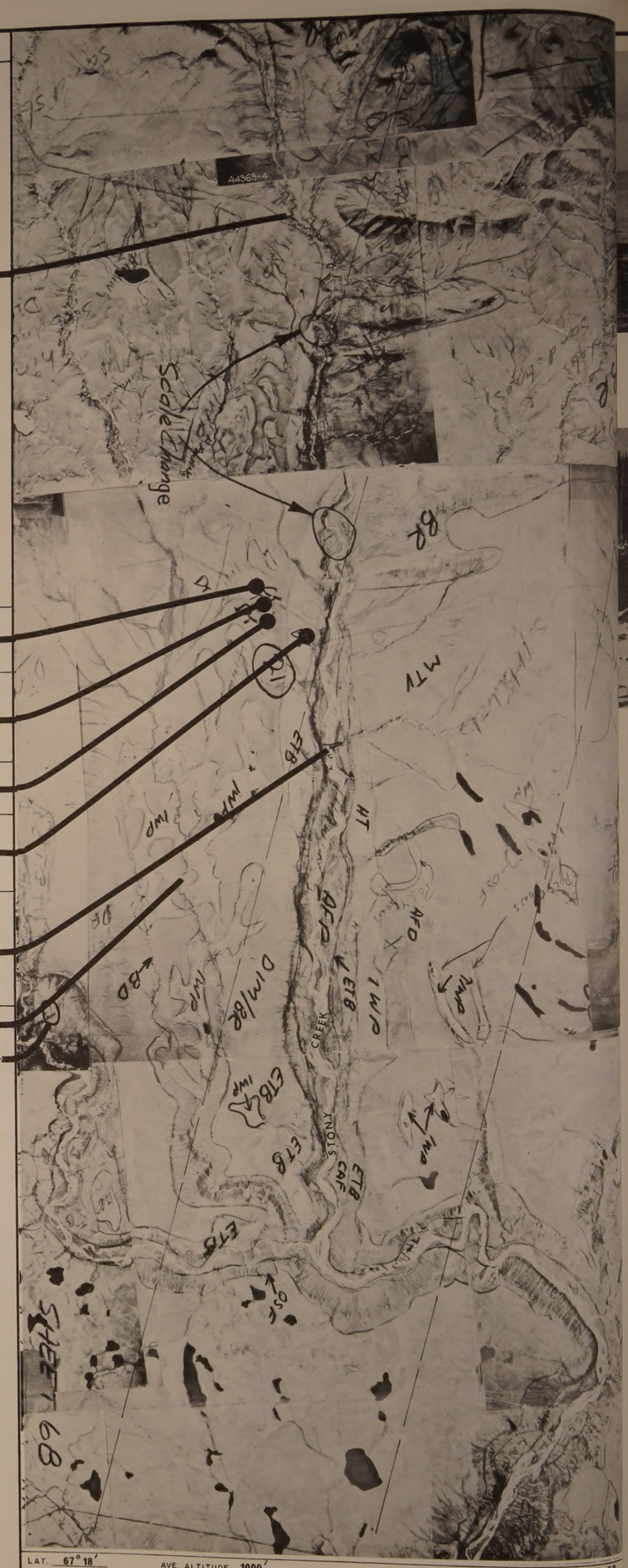
J. D. Mollard and Associates Limited

MAP SYMBOL — ABBREVIATED DESCRIPTION OF TERRAIN

- BR - Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions
- MTV - Smooth streaked slopes in foothill localities; mainly thick ice-rich organic silt (loessial) with minor sand and gravel inclusions on extensive, flatter lower slopes to thin colluvial or residual bouldery to gravelly silt over bedrock below base of bedrock slopes, with stratigraphy often inferrable from local geomorphic setting
- IWP - Ice-wedge polygons; mainly developed in ice-rich silty deposits
- HT - High terrace; predominantly ice-rich silt with some pebbles and minor gravel and sand inclusions
- ETB - Steep, eroding thaw banks; includes banks containing silt, sand, gravel, till or bedrock.
- DIM - Dead-ice moraine; mainly "ablation" till, often with ice-rich silt or silty clay mantle locally
- OSF - Old slide features; mainly weak stratified (sand over silt and clay) glacial-lake deposits or bentonitic clay shales
- BD - Beaded drainage
- AFD - Variable-textured alluvial fans; mainly thin silt over sand and gravel with major textural variations often inferrable from local geomorphic (depositional) setting

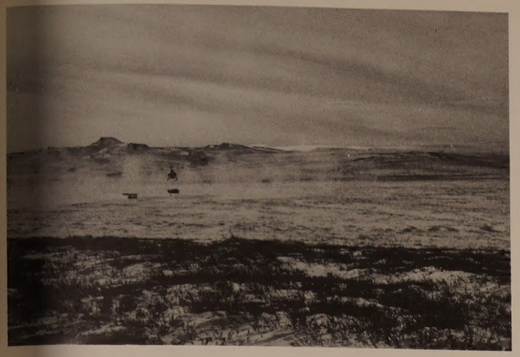
SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
			Deeply incised river valley
21 B_T	Grass and moss hummocks 6" diameter, 6" to 8" in height.	0 - 1' ORGANIC 1' - 6' SILT, organic, ice lenses(Vr) 6' - 21' CLAY, silty, trace of gravel ice crystals and lenses (VrVx)	21 B_T Test hole location in poorly drained area of ice-wedge polygon.
21 C_T	Grass and moss hummocks 6" to 8" diameter by 6" to 8" in height.	0 - 1' ORGANIC 1' - 2' SILT, organic, frozen at 1½' 2' - 4½' ICE 4½' - 11' SILT-CLAY, ice lenses and crystals, (VrVx) 11' - 21' SILT, clayey, ice lenses and crystals (VxVr)	21 C_T Test hole in same terrain as 21 B_T. Picture 1 overlooks depression from vicinity of test hole 21 D_T. Snow cover obscured possible observations of type and geometry of polygons.
21 D_T	Grass and moss hummocks 3' to 4' diameter by 1½ to 2' in height.	0 - 1' ORGANIC 1' - 2' SILT, organic, frozen 2' - 48' CLAY, silty, ice lenses and crystals (VxVr)	21 D_T On crest of knoll - See picture 2 with drill base on site.
21 E_T	Grass and moss hummocks 1' to 1½' diameter by 1' in height.	0 - 1' ORGANIC 1' - 2' SILT, organic, frozen at 14" ice lenses (Vr) 2' - 4' SILT, sandy, ice lenses (Vr) 4' - 7' SANDSTONE, fine-grained, black	21 E_T Test hole located on old river terrace.
			21 A_0 Braided flood plain. River actively degrading. Surface material mainly gravel, cobbles and boulders but with some sand and silt in inactive braids as shown in Picture 3. Rock samples identified as argillite and fine-grained greywacke sandstone. Picture 4 shows river actively eroding into gravel deposit on north bank. Pictures 5 and 6 show river undercutting into south bank just upstream of 21 A_0.
			Beaded drainage
			Ice-wedge polygons



LAT. 67°18'
LONG. 135°40'
AVE. ALTITUDE 1000'
MEAN ANNUAL AIR TEMP. 16°F

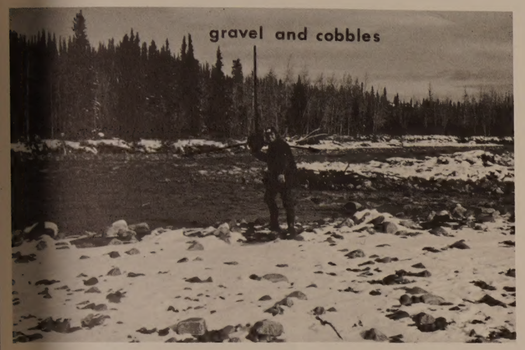
SITE NO. 21 SHEET NO. 68
PLATE NO. 44



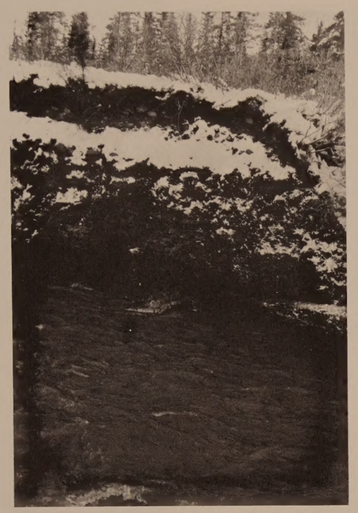
Picture: 1 Looking from site 21 D_T to drill on site 21 C_T in ice wedge polygon area.
Site: 21 C_T

Picture: 2 Looking across site. Drill rig base on drill hole.
Site: 21 D_T

Picture: 3 Active flood plain. Note sands and silts in stream bed.
Site: 21 A_0

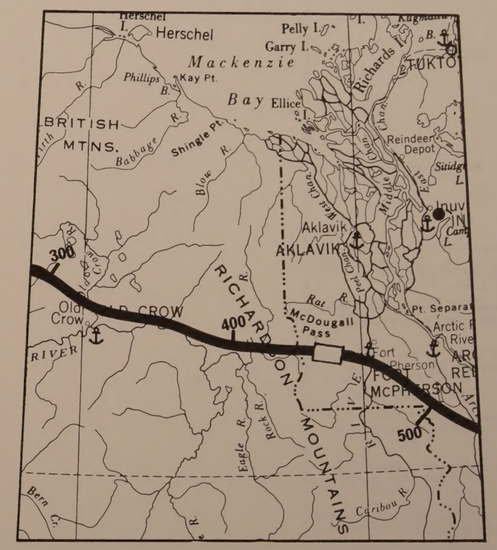


Picture: 4 Active flood plain. Gravel and cobbles exposed on north bank.
Site: 21 A_0



Picture: 5 Serrated edge of south bank of river cutting through active flood plain. Tree cover, surface organic layer, then till layer to water level.
Site: 21 A_0

Picture: 6 Serrated edge of south bank of river cutting through active flood plain. Note gravel in stream bed, till layer below organic surface layer.
Site: 21 A_0



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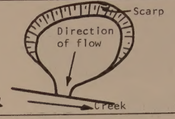
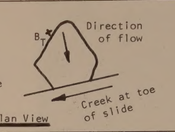
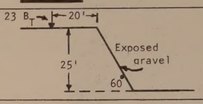
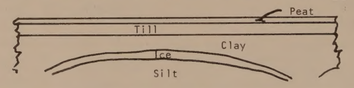
Pictures taken late September, 1970.

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE				
	TITLE: Photo Mosaic and Terrain Investigation MILE 441 TO MILE 455				
	SUBMITTED: R Jewell	DATE: Dec/70	SITE No.: 21	PLATE No.: 45
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	APPROVED: Eurlpeer	DATE: Dec/70	SHEET No.: 68	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
				22 A_0 Actively eroding thaw banks in low plastic silt west of river. Pictures 4 and 5 show views of the bank.
				22 B_0 On circular spot patterns on mosaic. Appear to be peat mounds on high plateau. Mounds are approximately 100 yds. in diam. and 15 to 20' in height, are well drained and covered with lichen and stunted willows. Frost depth measured at 36 in. Picture 1 shows typical surface cover and mound profile.
				22 D_0 On mountain lake. There is no visible degradation around shoreline. Picture 2 shows test pit on peat adjacent to lake, together with the lichen and grass cover. Some silt encountered in the peat below 12" depth. Frost depth adjacent to lake is 36" decreasing to 12" at 40' from lake edge.
				23 E_0 "Lumpy" pattern on mosaic. Appears to be due to peat and lichen covered mounds and the surrounding drainage pattern, Picture 3. Frost depth measured at 24 to 30 inches at top of mound decreasing to 12" in drainage path at base of mound.
	23 F_T	Grass and moss hummocks to 12" in height, occasional dwarf birch to 3'.	0 - 1' ORGANIC, frozen at 1' 1' - 21' CLAY, organic, ice lenses and crystals (Vs, Vx)	23 F_T Test hole in location shown in Picture 6.
				22 E_0 Ice wedge polygons.
				22 C_0 On old flow slide in valley wall. Picture 7 shows view of top of slide which is shaped as sketched. Freshly tilted trees and overthrusting toward the top of the slide noted. Picture 8 of the toe of the slide shows a series of water filled cracks along the toe. The entire slope is wet. 
				Deposits of boulders, cobbles and gravel in flood plain.
				23 A_0 On flow slide. Slide is shaped as sketched and appears to have occurred in gravel or till strata. Picture 9 shows general view of slide including location of test hole 23 B_T. The gravel exposed by the slide can be seen in Picture 11, taken of the bank just north of B_T and Picture 10 of the base of the slide. 
	23 B_T	Hummocks of grass and moss to 12" in height, dwarf birch to 2', light black spruce to 15'.	0 - 1' ORGANIC 1' - 5' SILT, organic, ice lenses and crystals (Vx, Vr) 5' - 6' SAND, silty 6' - 10' GRAVEL, silty, no visible ice (Nbe)	23 B_T Test hole on bank within 20 ft. of edge of slide. For location see Picture 9. 
				Recent mud flow; broken off trees still green.
				23 C_0 On large recent mudflow. The surface of the slide is very soft and has no regrowth. Picture 12 shows flow from opposite side of the valley and includes evidence of a previous slide at the same location. At the head of the slide is a vertical exposure of the original strata which is supported by the cantilevering action of thick ice lenses - see Picture 13. Picture 14 shows the profile of muskeg over till over clay over ice rich silt. The strata are not uniform in thickness across the exposure as shown in Picture 13.  Picture 15 shows a mudflow tongue approximately 3 ft. wide which was observed on one side of the slide. Several ice deposits in the exposure at the head of the slide indicate sources of groundwater.
				23 I_0 Ice-wedge polygons.

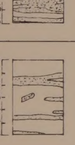
SEGREGATED ICE NOT VISIBLE BY EYE

- **Nf** POORLY BONDED
- **Nbn** WELL BONDED - NO EXCESS ICE
- **Nbe** WELL BONDED - EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

- **Vx** INDIVIDUAL ICE INCLUSION
- **Vc** ICE COATINGS ON PARTICLES
- **Vr** RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS
- **Vs** STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



- **ICE & SOIL** ICE WITH SOIL INCLUSIONS
- **ICE** ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL - ▨ ICE - □

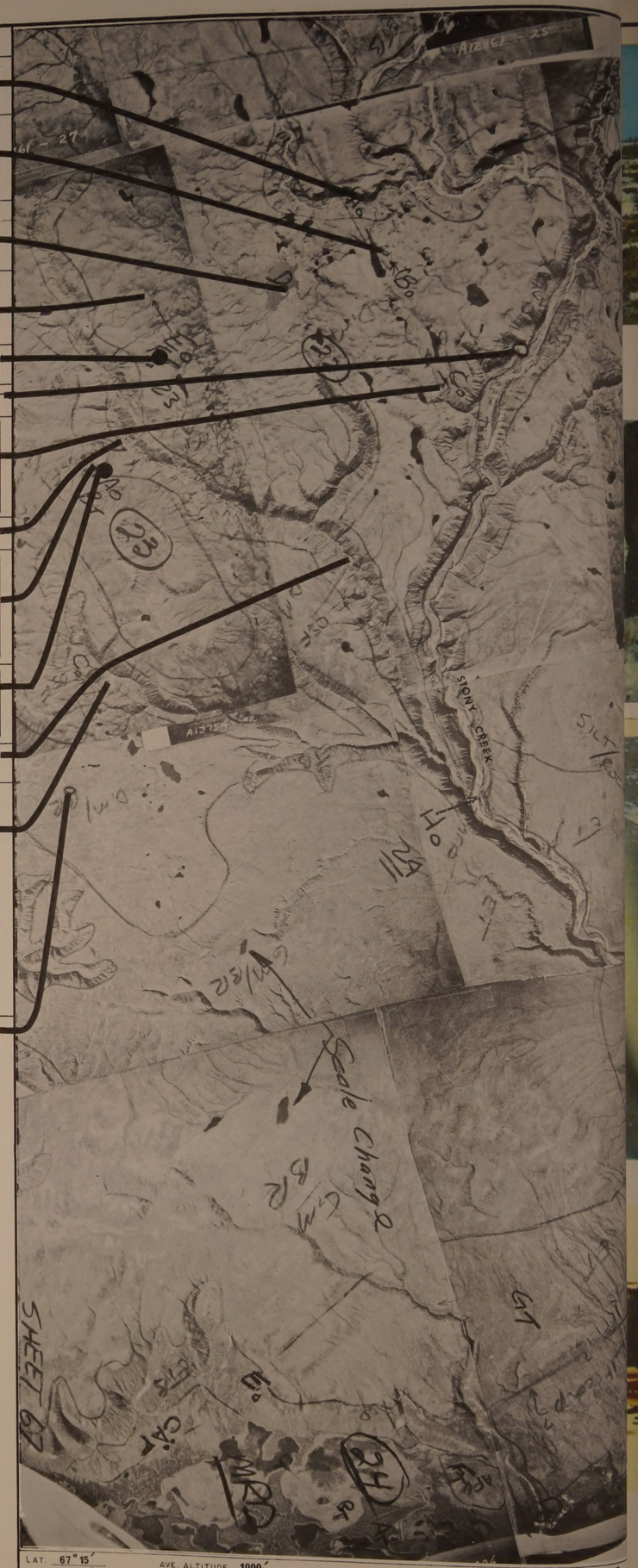
AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
AFD	Variable-textured alluvial fans; mainly thin silt over sand and gravel with major textural variations often inferrable from local geomorphic (depositional) setting
MRD	Mackenzie River delta deposits; mainly ice-rich organic silt and sand with minor clay strata
CAF	Coalescing alluvial fans and slopewash deposits; mainly ice-rich organic and inorganic silt and fine sand with minor pebbles locally
ETB	Steep, eroding thaw banks; includes banks containing silt, sand, gravel, till or bedrock
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
BD	Beaded drainage
DIM	Dead ice-moraine; mainly "ablation" till, often with ice-rich silt or silty clay mantle locally
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions
OSF	Old slide features; mainly weak stratified (sand over silt and clay) glacial-lake deposits or bentonitic clay shales
AFP	Active flood plain; mainly exposed sand, gravel and cobbles with boulders locally
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "



LAT. 67°15'
LONG 135°15'

AVE. ALTITUDE 1000'
MEAN ANNUAL AIR TEMP. 17°F

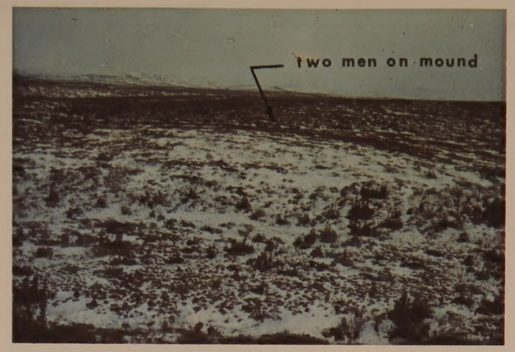
SITE NO. 22 & 23 SHEET NO. 67
PLATE NO. 46

Picture: 1 Circular mound on high plateau showing surface vegetation.

Site: 22 B_0

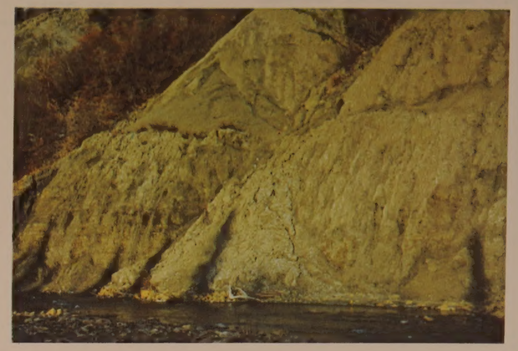
Picture: 2 Hand excavation in peat.

Site: 22 D_0



Picture: 3 Circular mound believed to produce lumpy pattern on mosaic.

Site: 23 E_0



Picture: 4 Close-up of bank in Picture 5.

Site: 22 A_0

Picture: 5

View of 130' high thaw banks above flood plain.

Site: 22 A_0

Picture: 6

Drill site showing vegetation.

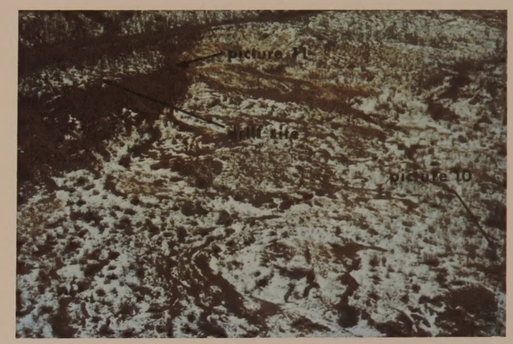
Site: 23 F_T

Picture: 7 View of top of old mud flow.

Site: 22 C_0

Picture: 8 View of toe of mud flow.

Site: 22 C_0



Picture: 9 View of top of slide showing exposed gravel faces and location of drill site.

Site: 23 B_T

Picture: 10

Gravel on base of slide.

Site: 23 A_0

Picture: 11 Gravel exposed in slide scarp 100' north of drill site.

Site: 23 B_T

Picture: 12

Overall view of mud flow.

Site: 23 C_0

Picture: 13 Exposed strata at head of mud flow. Note ice lenses.

Site: 23 C_0

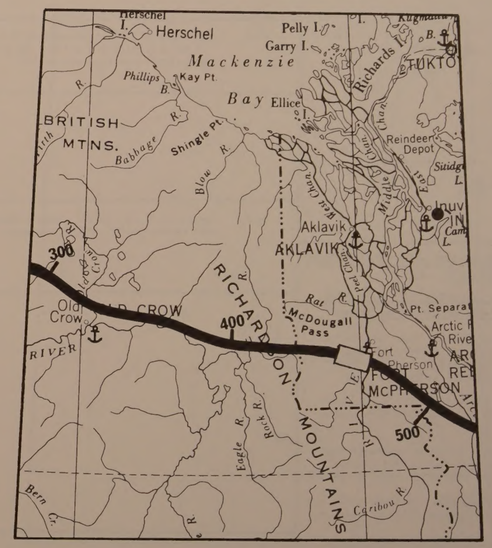
Picture: 14 Close-up of exposed strata. Note thick ice lense between clay and silt.

Site: 23 C_0

Picture: 15

View of recent flow path.

Site: 23 C_0



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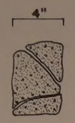
Pictures taken in late September, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE		
	TITLE: Photo Mosaic and Terrain Investigation MILE 453 TO MILE 468		
	SUBMITTED: L Jewell	DATE: Dec/70	SITE No.: 22&23
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	APPROVED: Cudpeer	DATE: Dec/70	SHEET No.: 67
			PLATE No.: 47

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

Nbn WELL BONDED – NO EXCESS ICE

Nbe WELL BONDED – EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL INCLUSIONS ICE WITH SOIL

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL – ICE –

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by–

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
AFD	Variable-textured alluvial fans; mainly thin silt over sand and gravel with major textural variations often inferrable from local geomorphic (depositional) setting
MRD	Mackenzie River delta deposits; mainly ice-rich organic silt and sand with minor clay strata
CAF	Coalescing alluvial fans and slopewash deposits; mainly ice-rich organic and inorganic silt and fine sand with minor pebbles locally
ETB	Steep, eroding thaw banks; includes banks containing silt, sand, gravel, till or bedrock
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
BD	Beaded drainage
DIM	Dead-ice moraine; mainly "ablation" till, often with ice-rich silt or silty clay mantle locally
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions
OSF	Old slide features; mainly weak stratified (sand over silt and clay) glacial-lake deposits or bentonitic clay shales
AFP	Active flood plain; mainly exposed sand, gravel and cobbles with boulders locally
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel

SEE PLATE No 3 for a comprehensive description of symbols.

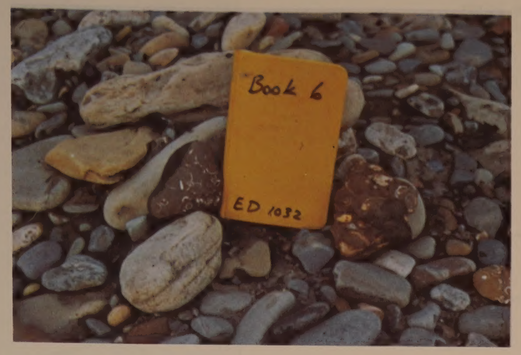
24 H_0				Observations made near the confluence of several streams in the mountains. Picture 1 shows gravel on river flood plain with exposed sandstone cliffs in the background. Pictures 2 and 3 show cobble and gravel deposits on the flood plain. Material is mainly sandstone and there are numerous shell fossils in the rock as shown in Picture 2. Gravel bars are evident along all the rivers in this area.
24 G_T	Hummocks of grass and moss to 8" in height, moderate willows to 4'; occasional black spruce to 10'.	0 - 2' ORGANIC, frozen at 2' 2' - 15' SILT, sandy (till-like) ice crystals and lenses (Vr, Vx) 15' - 20' SANDSTONE, weathered.	24 G_T	Test hole located on small burn at edge of terrace above scarp shown in Picture 4. The surface profile is relatively level near the scarp but merges into rolling ridge and gully topography leading back toward the mountains.
			24 D_0	Observation of banks around Shiltee Rock which is shown in Picture 5. The slopes on both sides of the rock outcrop were covered by fragmented angular talus. Rock samples taken on north side at location in Picture 6 were identified as sandstone and conglomerate. Different rock color indicates Peel River flood level.
24 F_T	Dense birch 25' to 40', some tamarack and spruce to 20', grass and moss.	0 - 1' ORGANIC 1' - 2' SILT, organic, frozen at 1' 2' - 15' SILT, highly organic, ice crystals and lenses (Vr, Vx) 15' - 30' SILT, sandy, ice crystals and lenses (Vr, Vx)	24 F_T	Test hole on alluvial fan. Picture 7 from the test site toward the edge of the alluvial fan and the Peel River.
			24 I_0	Steep valley. Picture 8 shows spruce to 25' on south facing, and willows to 6' on north facing sides. Valley walls slope approximately 45° and no fresh slides visible.
			24 E_0	Check of slopes in area showed no evidence of actively eroding thaw banks. Pictures 8 and 9 show typical banks in the area with their well-established tree cover.
			24 J_0	Avalanche track down steep slope shown in Picture 9. Has exposed boulders on bedrock toward top of slope.
24 C_T	Dense willows to 5', grass, moss, level ground.	0 - 1' ORGANIC 1' - 21' SILT, organic, frozen at 2' ice lenses and crystals (Vr, Vx), sandy from 15'.	24 C_T	Test hole in muskeg 20' from edge of lake as shown in Picture 10.
24 B_T	Dense willows to 8', grass hummocks to 10" high, level area.	0 - 1' ORGANIC 1' - 21' SILT, clayey, frozen at 2', ice lenses and crystals (Vr, Vx)	24 B_T	Test hole in muskeg in old lake infill area as shown in Picture 11.
24 A_T	Heavy willows to 15', spruce to 50', flat ground except for mounds around bases of large white spruce.	0 - 2' ORGANIC 2' - 3' SILT, clayey, ice lenses and crystals (Vx, Vr) 3' - 4½' ICE 4½' - 30' SILT, clayey, ice lenses (Vr, Vx)	24 A_T	Test hole in tall trees. Picture 12 of test site indicates size of trees encountered.

LAT. 67° 15'
LONG. 134° 58'
AVE. ALTITUDE 300'
MEAN ANNUAL AIR TEMP. 17°F

SITE NO 24 SHEET NO. 67
PLATE NO. 48

Picture: 1 River valley incised into sandstone bedrock. . Note active flood plain, scree slopes

Site: 24 H_0



Picture: 2 Close-up of active flood plain material. Note shell fossils.

Site: 24 H_o

Picture: 3

Excavation in flood plain material showing gradation of gravel.

Site: 24 H_0

Picture: 4 View of drill hole site.

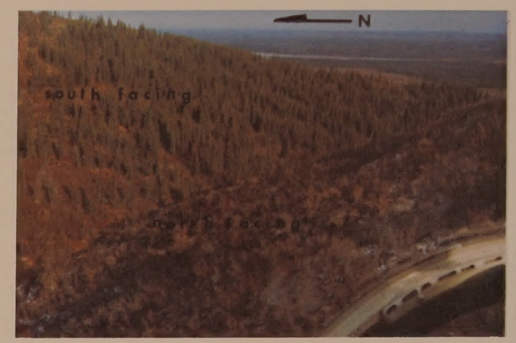
Site 24 G_T

Picture: 6 Talus slope on north side of Shiltee Rock. Identified as sandstone and conglomerate

Site: 24 D_0

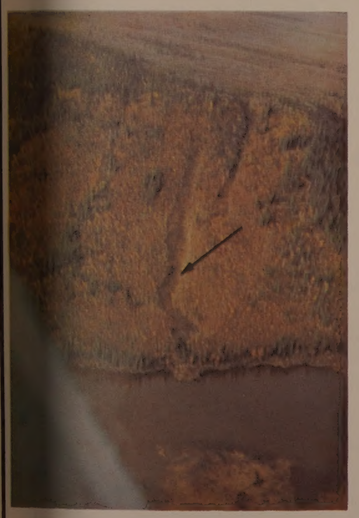
Picture: 7 View across drill hole site.

Site: 24 F_T



Picture: 8 Gully cut into plateau above river. Note difference between tree cover on north facing and south facing sides of gully

Site: 24 I_0



Picture: 5

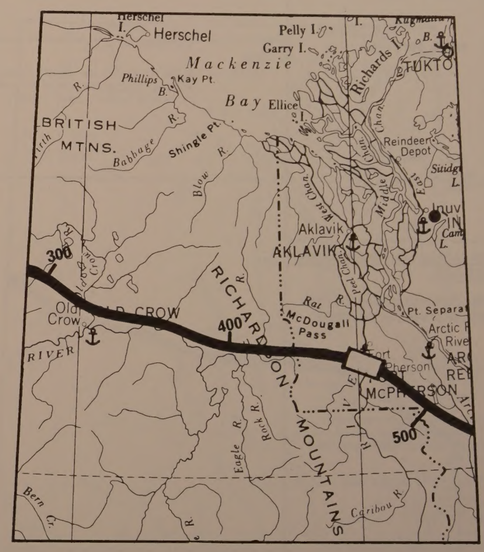
View of Shiltee Rock from river.

Site: 24 D_0

Picture: 9

View of avalanche trail.

Site: 24 J_0



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Picture: 10 View of drill hole site.

Site: 24 C_T

Picture: 11 View of drill hole site.

Site: 24 B_T

Picture: 12 View across drill hole site.

Site: 24 A_T

Pictures taken in late September, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER EDMONTON CALGARY REGINA WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 455 TO MILE 468

SUBMITTED	DATE	SITE No.	PLATE No.
R Jewell	Dec/70	24	49
APPROVED	DATE	SHEET No.	
Everpeer	Dec/70	67	

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL INCLUSIONS ICE WITH SOIL

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
WT	Whitish-toned peatlands on airphotos; mainly thick peat deposits in hollows on Peel Plain usually over thin silt over till or on till with shale at about 20 to 30 feet.
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions
SB	String bog (ribbed fen); mainly deep peat deposits
BD	Beaded drainage
MK	Muskeg, swamp, marsh, bog; includes all unpatterned peatlands
L	Lakes; mainly large oriented thaw lakes
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
SP	Speckled pattern of small ponds on undulating to rolling plain; mainly thin to thick ice-rich loessial silt over till or bedrock or sand and gravel

SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE
45 A_T	Sparse black spruce 2' to 10' in height, grass clumps to 12" in height, moss and lichen.	0 - 3½' PEAT, frozen at 2', ice lenses and inclusions (Vx, Vr) 3½' - 7' SILT, and SAND, clayey, (till-like), ice lenses and inclusions (Vx, Vr) 7' - 9' GRAVEL, silty, ice inclusions (Vx) 9' - 12' CLAY and SILT 12' - 30' SHALE, no visible ice (Nbn)
45 B_T	Moderate black spruce to 10', dwarf birch to 3', lichen covered peat mounds to 12" high.	0 - 1' ORGANIC 1' - 10' SILT, sandy, (till-like), frozen at 2', ice lenses and inclusions (Vx, Vr) 10' - 20' SHALE, bedrock
45 C_T	Moderate black spruce to 6' and tamarack to 12', dwarf birch to 3', grass and moss hummocks to 2' in height, water between hummocks.	0 - 3' PEAT, frozen at 2', ice lenses and inclusions (Vx, Vr) 3' - 17' SILT, clayey, (till-like), ice lenses and inclusions (Vx, Vr) 17' - 20' SHALE, grey
45 D_T	Dense black spruce to 20' in height, dwarf birch, grass and moss hummocks to 1½' in height, some lichen.	0 - 1' ORGANIC 1' - 5' SAND, silty, (till-like), frozen at 1', ice lenses and crystals (Vx, Vr) 5' - 25' SAND and GRAVEL, silty 25' - 30' SHALE

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

Bedrock outcropping

Lake completely infilled with grass.

Lake infilling with grass on north side at mouth of stream.

Poorly drained area - string bog (SB)

Grass-infill on western edge of small lake.

Beaded drainage

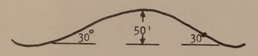
45 A_T Test hole in string bog. Picture 1 indicates surface cover.

Cut line - crosses string bog adjacent to 45 A_T site.

45 B_T Test hole in circular depressional area. White tone comes from lichen. Picture 2 indicates surface cover.

45 C_T Test hole. Picture 3 shows surface cover in this poorly drained area.

45 D_T Test hole on crest of densely timbered ridge. The ridge is rounded (see sketch). Picture 4 looks up the slope toward the test site.



Lake infilling at western end by grass.

Grass island in lake.

Large patch of lichen.

Lake infilling with grass on north side.

String bog and sedge meadow.

Grass infilling on north side.

Well-defined banks on lake; approximately 5' high.

Treed island in lake.

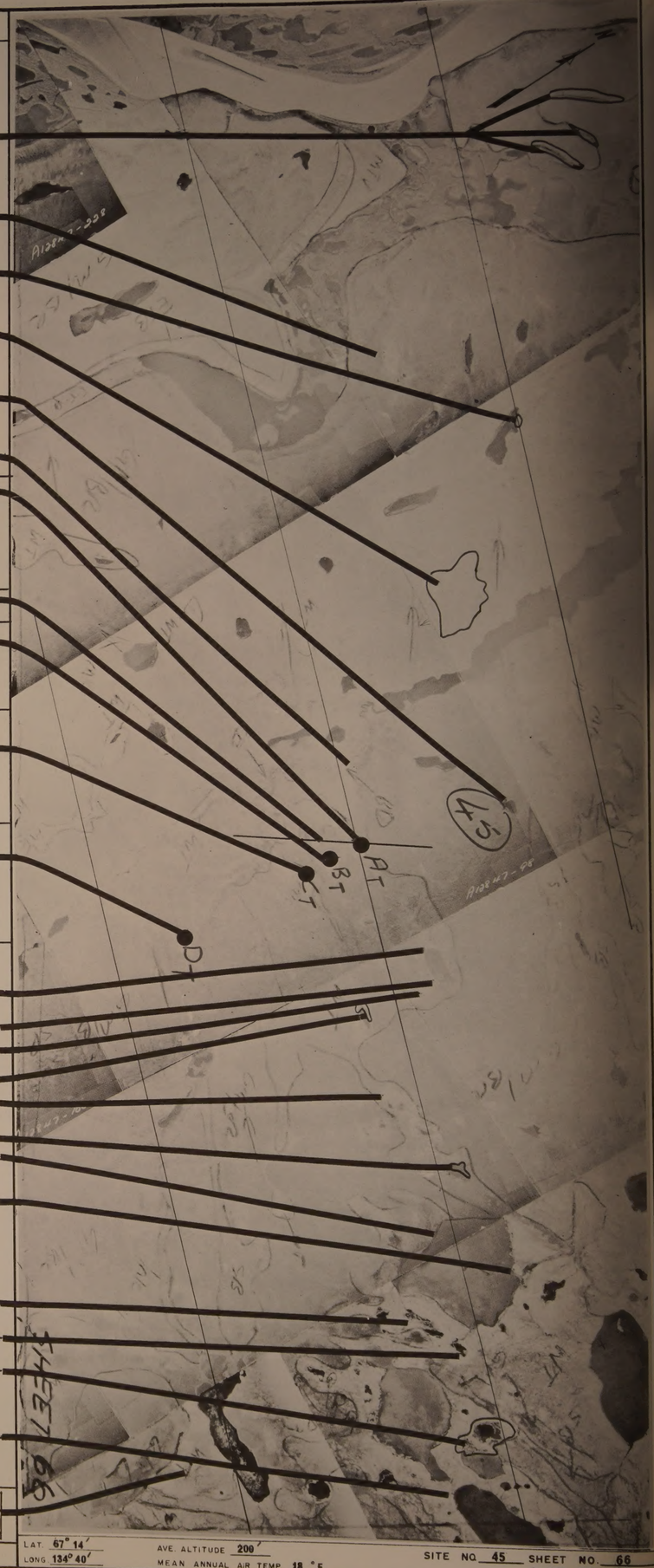
Grass-infilling in lake.

Grass-infilling in lake.

Grass-infilling in lake.

Well-defined banks on lake; approximately 5' high.

The WT area is generally poorly drained and most of the smaller lakes are infilling with string bog and sedge meadow features predominating. The vegetation is black spruce to 10' in height with masses of white-toned lichen surface cover.



LAT. 67° 14'
LONG 134° 40'

AVE. ALTITUDE 200'
MEAN ANNUAL AIR TEMP. 18 °F

SITE NO. 45 SHEET NO. 66
PLATE NO. 50

Picture: 1 Drill hole site

Site: 45 A_T

Picture: 2 Drill hole site

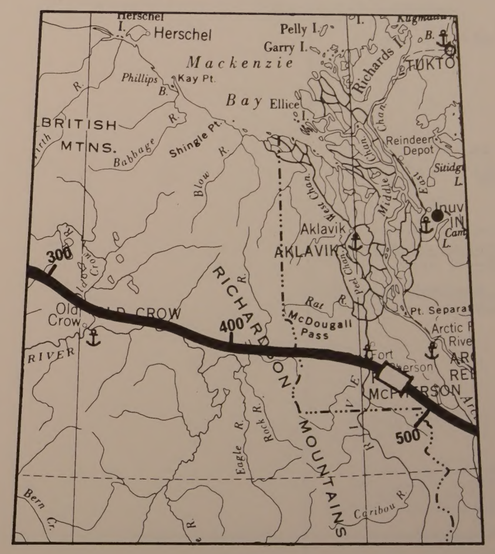
Site: 45 B_T

Picture: 3 Drill hole site

Site: 45 C_T

Picture: 4 Drill hole site

Site: 45 D_T



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Pictures taken in late September, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE			
	TITLE: Photo Mosaic and Terrain Investigation MILE 467 TO MILE 482			
	SUBMITTED: L Jewell	DATE: Dec/70	SITE No.: 45	PLATE No.: 51
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	APPROVED: Cardpeer	DATE: Dec 70	SHEET No.: 66	

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Ndn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

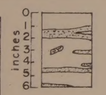
Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL — ABBREVIATED DESCRIPTION OF TERRAIN

GM - Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally

WT - Whitish-toned peatlands on airphotos; mainly thick peat deposits in hollows on Peel Plain, usually over thin silt over till or on till with shale at about 20 to 30 feet

L - Lakes; mainly large oriented thaw lakes

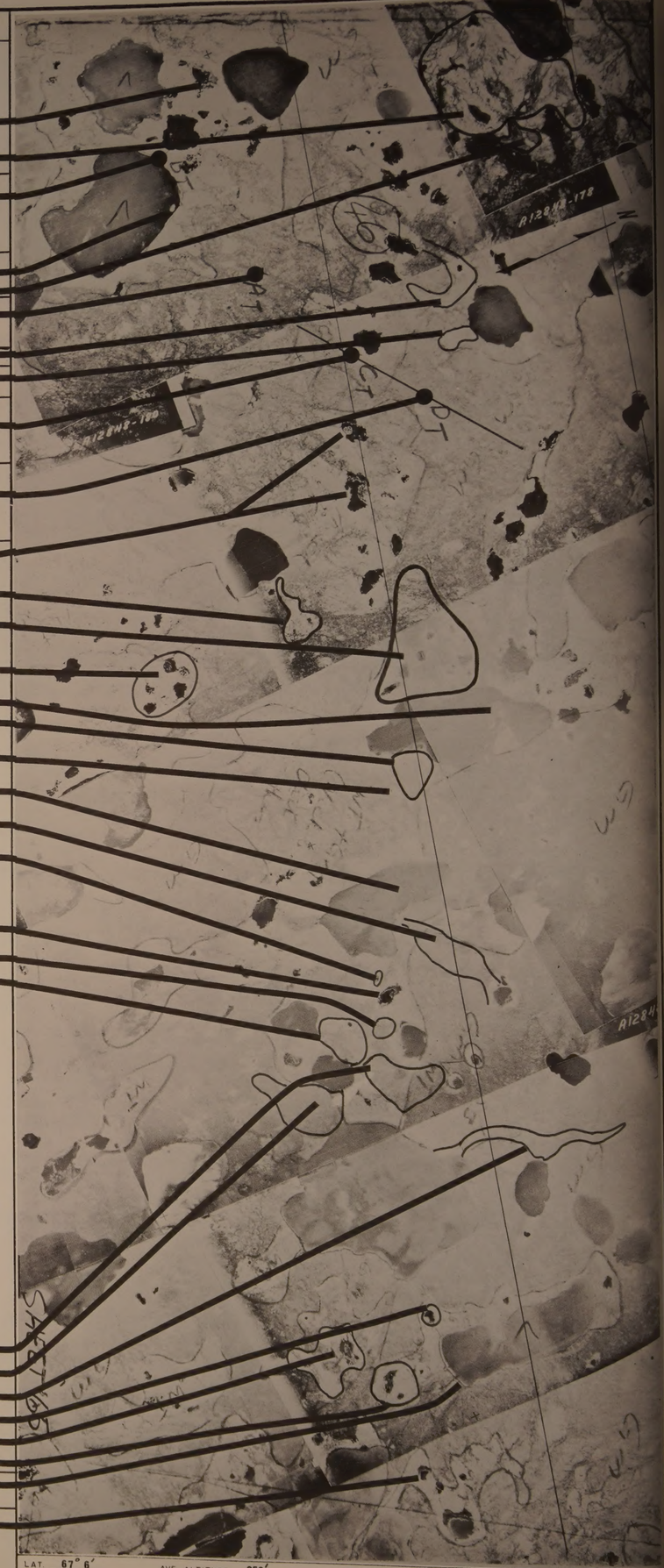
SB - String bog (ribbed fen); mainly deep peat deposits

SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
			Grass-infilling all around lake edges.
			Area poorly drained and swampy.
46 B_T	Old burn area now covered with grass and moss hummocks to 6" in height. Lichen over most of the area. Dense black spruce to 20' in height line larger lake.	0 - 10' PEAT, frozen at 1½', ice lenses and inclusions (Vx, Vr) 10' - 15' CLAY, very silty, ice lenses and inclusions (Vx,Vs) 15' - 26' SILT, sandy, (till-like), ice inclusions. (Vx)	46 B_T Test hole in white toned area between lakes. Picture 1 shows vegetation at the site.
			Grass island in lake.
			Small lake and delta grass infilling
46 A_T	Heavy dwarf birch to 4', grass and moss hummocks to 1' in height, dense black spruce to 35' surround site.	0 - 1' ORGANIC 1' - 20' SAND, silty, (till-like) frozen at 1½', ice inclusions (Vx), gravelly below 15',	46 A_T Test hole in darker area within white-toning on mosaic. Picture 2. shows vegetation at the site.
			String bog with sparse tree growth.
			Heavy lichen growth on peat plateau raised 3' to 4' above surrounding area.
46 C_T	Old burn area within white toned complex. Sparse black spruce to 15', lichen covered hummocks to 12" in height, over most of the area.	0 - 4' PEAT, frozen at 2', ice lenses and inclusions (Vx, Vr) 4' - 30' SILT, sandy, (till-like), ice lenses and inclusions (Vr, Vx)	46 C_T Test hole adjacent to seismic cut line. Picture 3 shows lichen adjacent to test site which was in a small depression without lichen cover.
46 D_T	Heavy black spruce to 25' in height, dwarf birch to 3'. Grass and moss hummocks to 8" in height.	0 - 2' ORGANIC, silty 2' - 35' SAND, silty, clayey, (till-like). Frozen at 2', ice inclusions (Vx) 35' - 40' SHALE, soft.	46 D_T Test hole adjacent to seismic cut line. Picture 4 at edge of site shows vegetal cover.
			Grass infill at center and edges of lakes.
			String bog with lichen growth on higher areas.
			Swamp and hummocky terrain.
			Lakes almost completely grass infilled.
			Heavy growth of spruce.
			String bog and sedge meadows with trees in pond pattern.
			Lichen
			Picture 5 taken October 4, 1970 from helicopter.
			String bog.
			Thaw ponds in lichen white-toned complex.
			Lake infilling by grass from all sides.
			Numerous small thaw ponds
			Infill area of grass with treed islands.
			String bog and sedge meadow
			String bog and sedge meadow
			String bog and sedge meadow
			Small lake grass-infillling
			Lakes in this area almost completely grass-filled.
			Grass-infill and heavy tree growth.
			Picture 6 shows edge of lake including grass-infill. Spruce to 25' just off R.H. edge of picture adjacent to lake.
			Beaded drainage in drainage path within white toned area.

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "



LAT. 67° 6′ LONG. 134° 18′ AVE. ALTITUDE 250′ MEAN ANNUAL AIR TEMP. 18 °F

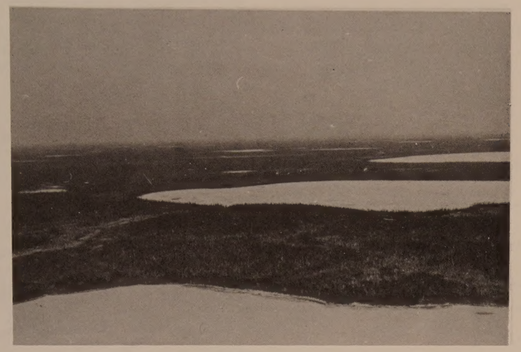
SITE NO. 46 SHEET NO. 65 PLATE NO. 52

Picture: 1
Site: 46 B_T
Drill hole site showing lichen surface cover.

Picture: 2
Site 46 A_T
Drill hole site showing surface cover.

Picture: 3
Site 46 C_T
Drill hole site showing lichen surface cover.

Picture: 4
Site 46 D_T
Dense black spruce adjacent to site.



Picture: 5
Site 46 E_0
Aerial view of general area showing frozen lakes.

Picture: 6
Site 46
Grass infill at edge of lake. Note black bear.

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Pictures taken in late September, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 482 TO MILE 496

SUBMITTED	DATE	SITE No.	PLATE No.
L Jewell	Dec/70	46	53
APPROVED	DATE	SHEET No.	
Ewlpeen	Dec/70	65	

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE.

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK.

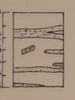
Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ICE-

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL — ABBREVIATED DESCRIPTION OF TERRAIN

MK - Muskeg, swamp, marsh, bog; includes all unpatterned peatlands

GM - Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally

WT - Whitish-toned peatlands on airphotos; mainly thick peat deposits in hollows on Peel Plain, usually over thin silt over till or on till with shale at about 20 to 30 feet

TK - Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand

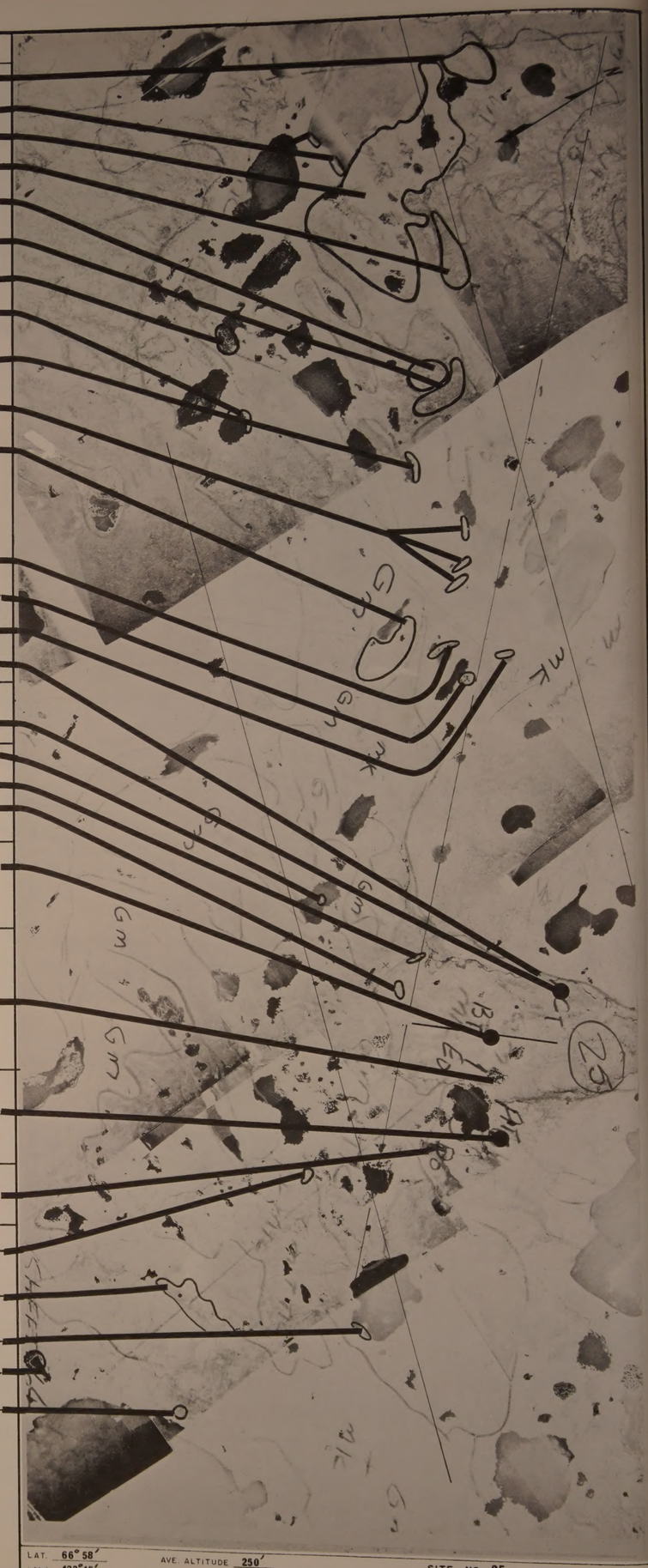
SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE		RECONNAISSANCE OBSERVATION NOTES
				Area of numerous peat plateaus.
				Linear active thaw banks.
				Area of grass-infilling lakes.
				Numerous small ponds and peat plateaus.
				Area of developing thaw ponds.
				Numerous peat plateaus.
				Lake infilling with grass at southern end.
				Grass-infill at northern end of lake.
				Grass-infill at northern end of lake.
				Approximate locations of small esker-like ridges.
				Numerous peat mounds to 3' or 4'.
				Grass-infill dividing lake.
				Grass-infill in small lake.
				Grass-infill on northern edge of lake.
				Beaded drainage
25 C_T	Sparse black spruce to 12' in height, heavy dwarf birch to 4' in height, grass and moss hummocks to 8" in height.	0 - 8' 8' - 14' 14' - 20'	PEAT, frozen at 2', ice lenses and crystals (Vr,Vx) SAND, fine silty, ice lenses and crystals (Vr, Vx) SHALE	25 C_T Test hole adjacent to creek.
				Grass island in lake.
				Esker-like ridge
				Well drained ridge with tree growth to 30'.
25 B_T	Grass and moss hummocks to 10 inches in height. Light black spruce to 20' adjacent to site.	0 - 2' 2' - 8' 8' - 15' 15' - 20'	PEAT, frozen at 2' SILT and CLAY, pebbles, ice lenses and crystals (Vr,Vx) SAND and SILT, gravelly. (till-like) ice lenses and crystals. SHALE	25 B_T Test hole adjacent to seismic cut line in muskeg terrain.
				25 E 0 Observation of vegetal mat on lake shown in Picture 1. Picture 2 is a closer view of typical "mat" composed of grasses apparently rooted in the lake bottom. Picture 4 shows sample of peat recovered from a test pit located near the helicopter shown in Picture 3. Frost depth was 18" at this location.
25 A_T	Sparse black spruce to 20' in height on old burn. Peat hummocks to 1' in height, lichen covered, water in lows.	0 - 10' 10' - 15' 15' - 25' 25' - 30'	PEAT, frozen at 2', ice lenses and crystals (Vr, Vx) SILT, clayey, ice lenses and crystals (Vr, Vx) GRAVEL, sandy, silty. (till-like) ice lenses and crystals (Vr,Vx) SHALE	25 A_T Test hole adjacent to lake. Picture 5 shows edge of lake and white toned area behind covered with lichen. Note floating vegetal mat at edge of lake and beaver lodge. Test site is 200' from edge of lake. Pictures 6 & 7 show close-up views of lichen on the shore of the lake. Foreground of Picture 6 is grass in floating vegetal mat.
				25 D_0 Observations of shore line of lake. Pictures 8, 9, & 10 show typical views. Bank height varies up to 5' and most of lake is infilled with vegetation.
				White toned lichen.
				String bog
				Linear active thaw banks.
				Grass-infill at western end of lake.
				Ice wedge polygons

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

NOTE: Nearly all of the lakes shown on this mosaic in the vicinity of the test hole sites are being infilled by grass to a major extent.



LAT. 66° 58′ LONG. 133° 45′ AVE. ALTITUDE 250′ MEAN ANNUAL AIR TEMP 18 °F

SITE NO. 25 SHEET NO. 64 PLATE NO. 54

Picture: 1
Floating vegetal mat in lake.

Site:
25 E_0

Picture: 2
Aerial view of vegetal mat. Close-up of Picture 1.

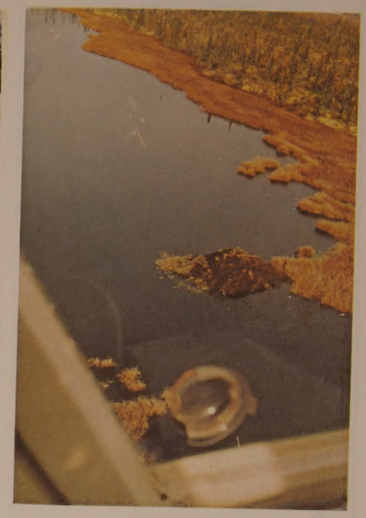
Site: 25 E_0

Picture: 3
Grass-infilling in lake with peat shoreline.

Site: 25 E_0

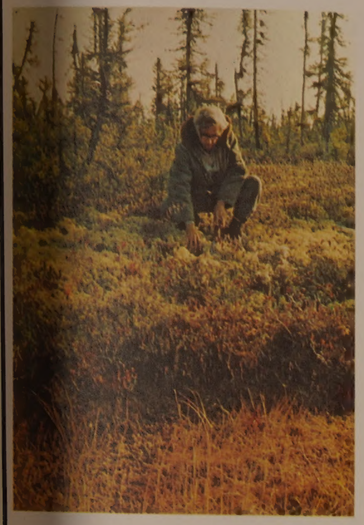
Picture: 4
Excavated soil shows sparse lichen and moss over peat.

Site: 25 E_0



Picture: 5
Aerial view of vegetal mat at edge of lake adjacent to test hole site. Note beaver lodge.

Site: Near
25 A_T



Picture: 6
Luxurient lichen on shore of lake adjacent to test hole site

Site: Near
25 A_T

Picture: 7
Close-up of lichen shown in Picture 6

Site: near
25 A_T

Picture: 8
Shoreline of lake checked for active thaw.

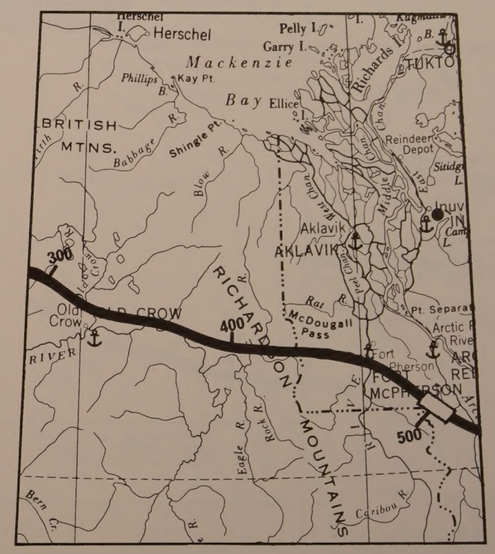
Site: 25 D_0

Picture: 9
Black spruce on edge of lake.

Site: 25 D_0

Picture: 10
5' high peat plateau forming lake shoreline.

Site: 25 D_0



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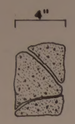
Pictures taken in late September, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE
	TITLE: Photo Mosaic and Terrain Investigation MILE 495 TO MILE 510
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: L Jewell — DATE: Dec/70 — SITE No.: 25 — PLATE No.: 55 APPROVED: Gulpen — DATE: Dec/70 — SHEET No.: 64

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

Nbn WELL BONDED – NO EXCESS ICE

Nbe WELL BONDED – EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

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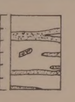


ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ▨ ICE- □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL — ABBREVIATED DESCRIPTION OF TERRAIN

MK - Muskeg, swamp, marsh, bog; includes all unpatterned peatlands

DIM - Dead-ice moraine; mainly "ablation" till, often with ice-rich silt or silty clay mantle locally

WT - Whitish-toned peatlands on airphotos; mainly thick peat deposits in hollows on Peel Plain; usually over thin silt over till or on till with shale at about 20 to 30 feet

BD - Beaded drainage

GM - Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally

SB - String bog (ribbed fen); mainly deep peat deposits

SEE PLATE No 3 for a comprehensive description of symbols

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE
26 D_T	Light black spruce to 20' in height, labrador tea, peat mounds to 12" in height.	0 - 4' PEAT, frozen below 2', ice inclusions (Vx) 4' - 15' SAND and SILT, clayey.(till-like) ice inclusions (Vx) 15' - 20' SHALE, grey.
26 B_T	Old burn close to thaw lake. Light black spruce to 20' in height, peat mounds to 2' in height.	0 - 10' PEAT, frozen at 2', ice lenses and crystals (Vx,Vr) 10' - 14' CLAY, silty, pebbles, ice lenses and crystals (Vx, Vr) 14' - 19' SILT, sandy, clayey. (till-like), ice lenses (Vr,Vs) 19' - 25' SHALE

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10'to 15' "
Light	15'to 25' "
Sparse	>25' "

RECONNAISSANCE OBSERVATION NOTES

Grass-infill

Ice-wedge polygons

This large lake has clear water, is shallow and has extensive grass-infilling at its shoreline.

Well drained and treed hummock.

Peat plateau in white-toned area.

Lake completely infilled with grass.

String bog.

Lake almost completely infilled with grass.

String bog.

Better drained ground with heavy tree cover.

String bog.

Ice-wedge polygons

Old lake completely infilled with grass.

Esker-like ridge

Ice wedge polygons

26 G_0 Pictures 1, 2 and 3 show ground movements on relatively flat area between IWP and small creek.

Old burn area adjacent to creek. The remaining trees are leaning in all directions.

String bog and sedge meadows.

26 F_0 Pictures 4 and 5 show observation point at edge of lake and include the vegetal mat infill as well as the sparse black spruce tree growth. A hand excavated pit at the site encountered consolidated peat with a layered structure as can be seen in Picture 6. Frost depth was found to vary from 12" to 18", being greatest in hollows.

26 D_T Test hole in string bog.

26 C_0 Observation of a series of peat mounds as seen from the air in Picture 7. Test pits were dug on top of one of the mounds and in an adjacent depression. Picture 8 of the higher one in which frost was encountered at 18" depth shows the lichen over peat profile. Picture 9 shows test pit in the depression as well as the vegetal cover in the area which consisted generally of grass only in the poorly drained depression, and lichen, shrubs and sparse black spruce to 8' in height on the better drained mounds. The depth to frost appeared to follow the contour of the mounds dropping abruptly to 6' at the depressions.

26 B_T Test hole in poorly drained white-tone area. Hole is adjacent to a large string bog complex similar to, but much larger and better defined than that shown in Picture 10.

26 E_0 Area indicated on the mosaic as having a "crack" pattern is shown in Picture 10. As shown by Pictures 11 and 12, which are close-ups of the same area, the crack pattern is believed to be due to different tonal patterns in a burned over section of a muskeg string bog.

Alternatively, Pictures 13 and 14 respectively show an area from 300' up and from the ground of peat mounds which may be interpreted as a "crack" pattern. The area has been burned over and the mounds have lichen on top. Frost depth was measured at 18". The drainage channels between the mounds average 3' lower than the top of the mounds.

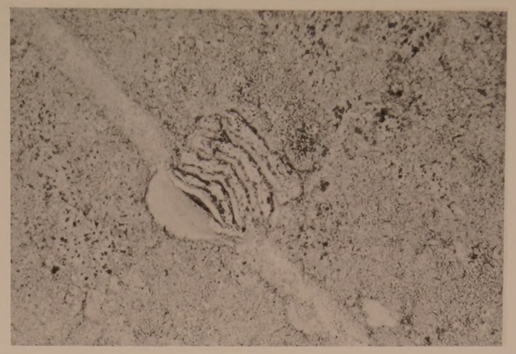
NOTE Area from 26 F_0 to 26 E_0 is very poorly drained, has extensive areas of string bogs and all of the lakes are shallow and almost completely infilled with grass.

LAT. 66°47′ LONG 133°30′ AVE. ALTITUDE 350′ MEAN ANNUAL AIR TEMP. 18°F

SITE NO. 26 SHEET NO. 63 PLATE NO. 56

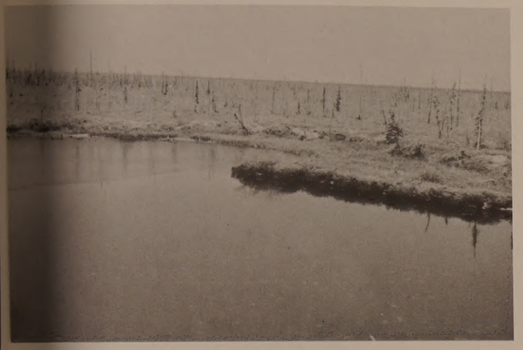
Picture: 1 View looking north at isolated ground movements.
Site: 26 G_0

Picture: 2 View of ground movements
Site: 26 G_0



Picture: 3 Close-up of ground movements. Scale indicated by seismic cut line, approx. 20' wide
Site: 26 G_0

Picture: 4 Old burn area adjacent to lake. Note grass-infill around shoreline.
Site: 26 F_0



Picture: 5 Low level view of shoreline in Picture 4.
Site: 26 F_0

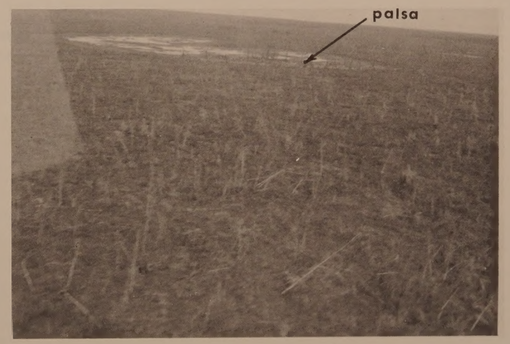
Picture: 6 Test hole shows layered consolidated peat.
Site: 26 F_0

Picture: 7 Aerial view of lichen covered peat mounds.
Site: 26 C_0

Picture: 8
Excavation in peat on top of mound. Lichen at surface.
Site: 26 C_0

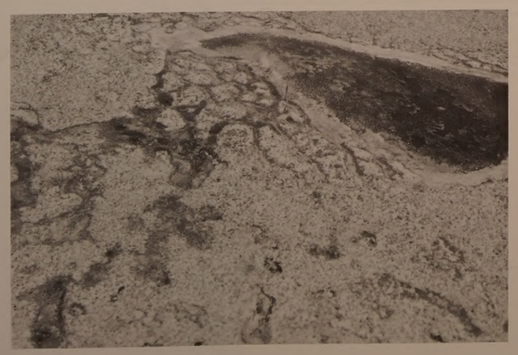
Picture: 9 Excavation in low area adjacent to area in Picture 8. Soft ground.
Site: 26 C_0

Picture: 10 View of area typical of "crack" pattern on mosaic.
Site: 26 E_0



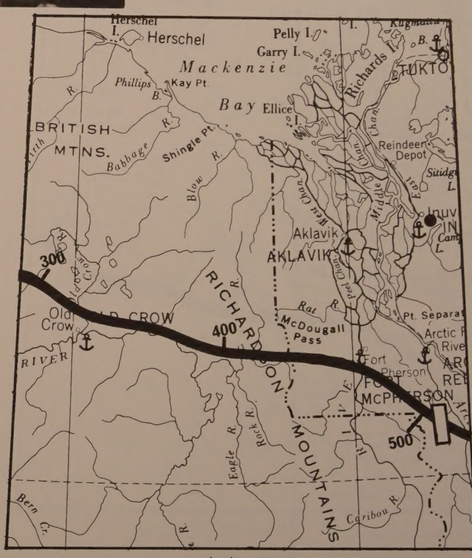
Picture: 11 View of peat swamp. Note burned trees, palsa on lakeshore
Site: 26 E_0

Picture: 12 Poorly drained peat swamp.
Site: 26 E_0



Picture: 13 "Crack" pattern from 300' above ground.
Site: 26 E_0

Picture: 14 Topography of old burn area showing peat mounds.
Site: 26 E_0



Index 2

Pictures taken in late September, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 508 TO MILE 514

SUBMITTED	DATE	SITE No.	PLATE No.
R Jewell	Dec/70	26	57
APPROVED	DATE	SHEET No.	
Cwilpeer	Dec/70	63	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

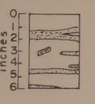
Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ▨ ICE- □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—
J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
SB	String bog (ribbed fen); mainly deep peat deposits
MK	Muskeg, swamp, marsh, bog; includes all unpatterned peatlands
→	Drumlinized and/or fluted surface; mainly isolated patches of silt over thin till over bedrock or over fluted bedrock
ET	Gently to moderately sloping water-eroded (sheet erosion) till or bedrock plain; mainly thin ice-rich silt or sand mantle over till or bedrock
HT	High terrace; predominantly ice-rich silt with some pebbles and minor gravel and sand inclusions
DIM	Dead-ice moraine; mainly "ablation" till, often with ice-rich silt or silty clay mantle locally
WT	Whitish-toned peatlands on airphotos; mainly thick peat deposits in hollows on Peel Plain, usually over thin silt over till or on till with shale at about 20 to 30 feet

A_0 Near vertical banks of layered sandstone to a maximum of 70' in height, average 40' in height. Picture 1 shows close-up of exposure identified as very fine grained sandstone. Some sections iron-stained. Banks appear relatively stable.

B_0 60' to 70' deep valley with steep banks of exposed layered sandstone, similar to that in Picture 1.

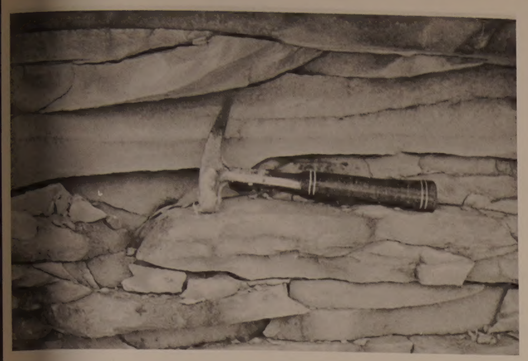
Very recent slide on east bank appears to be result of embankment undercutting by river.

C_0 Picture 2 shows relatively stable river banks.

D_0 Picture 3 shows undercutting by scour of island in Arctic Red River. Picture 4 is a close-up of the 10' high bank which was composed of dark grey to black organic, very fine cohesionless sand containing approximately 20% silt size particles.

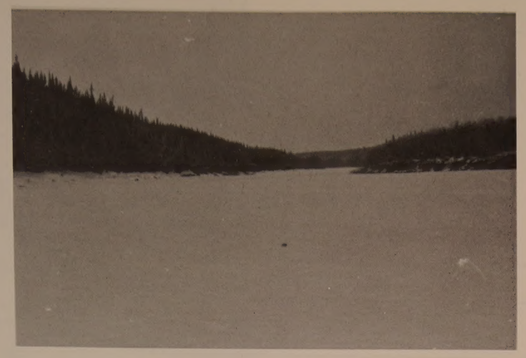
E_0 Appearance indicates beaded drainage.

RIVER
ARCTIC RED RIVER
SHEET 69
A 15723-208
ET
TK
WT
SB
SB
SB



Picture: 1 Sandstone exposed in vertical bank of river.

Site: A_0



Picture: 2 View looking south along river showing river bank profile.

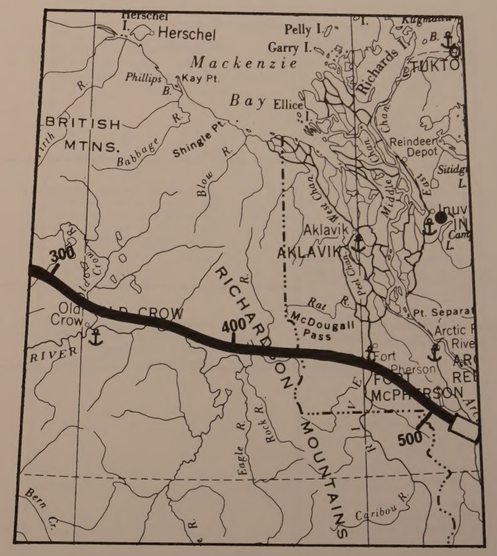
Site: C_0

Picture: 3 Aerial view of scour pattern on bank of island in Arctic Red River.

Site: D_0

Picture: 4 Close-up of scour on bank shown in Picture 3.

Site: D_0



Index 2

Pictures taken in late September, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE
	TITLE: Photo Mosaic and Terrain Investigation MILE 513 TO MILE 527
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: R Jewell DATE: Dec/70 SITE No.: between 26 & 27 PLATE No.: 59
	APPROVED: Earlpeer DATE: Dec/70 SHEET No.: 62

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
SEGREGATED ICE NOT VISIBLE BY EYE				
Nf POORLY BONDED				
Nbn WELL BONDED – NO EXCESS ICE				Abandoned oil rig site
Nbe WELL BONDED – EXCESS ICE				Well drained mound with trees to 40'.
				String bog.
VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK				
Vx INDIVIDUAL ICE INCLUSIONS				Heavy tree growth on well drained mound.
Vc ICE COATINGS ON PARTICLES				Treed islands in large lake.
Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS				String bog.
Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS	27 D_T	Light black spruce to 15', lichen covered mounds 3' in height and up to 20' across.	0 - 7' PEAT, frozen at 1', ice lenses and inclusions (Vr_1Vx) 7' - 20' SAND and GRAVEL, silty, (till-like) ice inclusions, (Vx)	27 D_T Test hole on muskeg 50' from small lake.
VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK				
ICE & SOIL ICE WITH SOIL INCLUSIONS	27 C_T	Grass tussocks and peat mounds as for B_T. Test hole area devoid of trees, water between clumps.	0 - 5' PEAT, frozen at 1', ice lenses and inclusions (Vr,Vx) 5' - 10' SILT, pebbles, considerable ice lenses and inclusions (Vr, Vx) 10' - 20' SAND, silty, clayey, (till-like) ice lenses and inclusions (Vr,Vx)	27 C_T Test hole in swampy area adjacent to the location of 27 B_T. The site was only 1' to 2' lower in elevation than the timbered "string".
ICE ICE WITHOUT SOIL INCLUSIONS	27 B_T	Light black spruce and tamarack to 25'. Peat mounds to 2' in height and grass tussocks 8" to 10" in diam. and 12" in height, water between clumps.	0 - 9½' PEAT, frozen at 3', no visible ice (Nbn) 9½' - 10' ICE 10' - 21' SAND, silty, clayey, (till-like) ice inclusions (Vx) to 15' depth then no visible ice (Nbn)	27 B_T Test hole in string of string bog.
LEGEND: SOIL – ICE –	27 A_T	Heavy black spruce to 40' occasional willow thickets to 8' in height, grass and moss covered hummocks to 2' in height.	0 - 2' PEAT, frozen at 1' 2' - 16' SAND, silty, clayey, (till-like) ice inclusions (Vx)	27 A_T Test hole on well drained ridge adjacent to string bog. Ridge height approximately 50'.
				NOTE: There are numerous string bogs in the test hole area
				Ice wedge polygons
				String bog.
				27 F_0 Observation of west bank of river. Bank is 40' in height and sloped as shown in Pictures 2 and 3. Rock in bank and on river edge is mostly fine grained sandstone with some quartzite occurring as water worn gravel at water's edge. Pictures 4 and 5 show sandstone bedrock exposure.
				27 F_0 Picture 1 shows general area looking downstream along Arctic Red River.

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by–

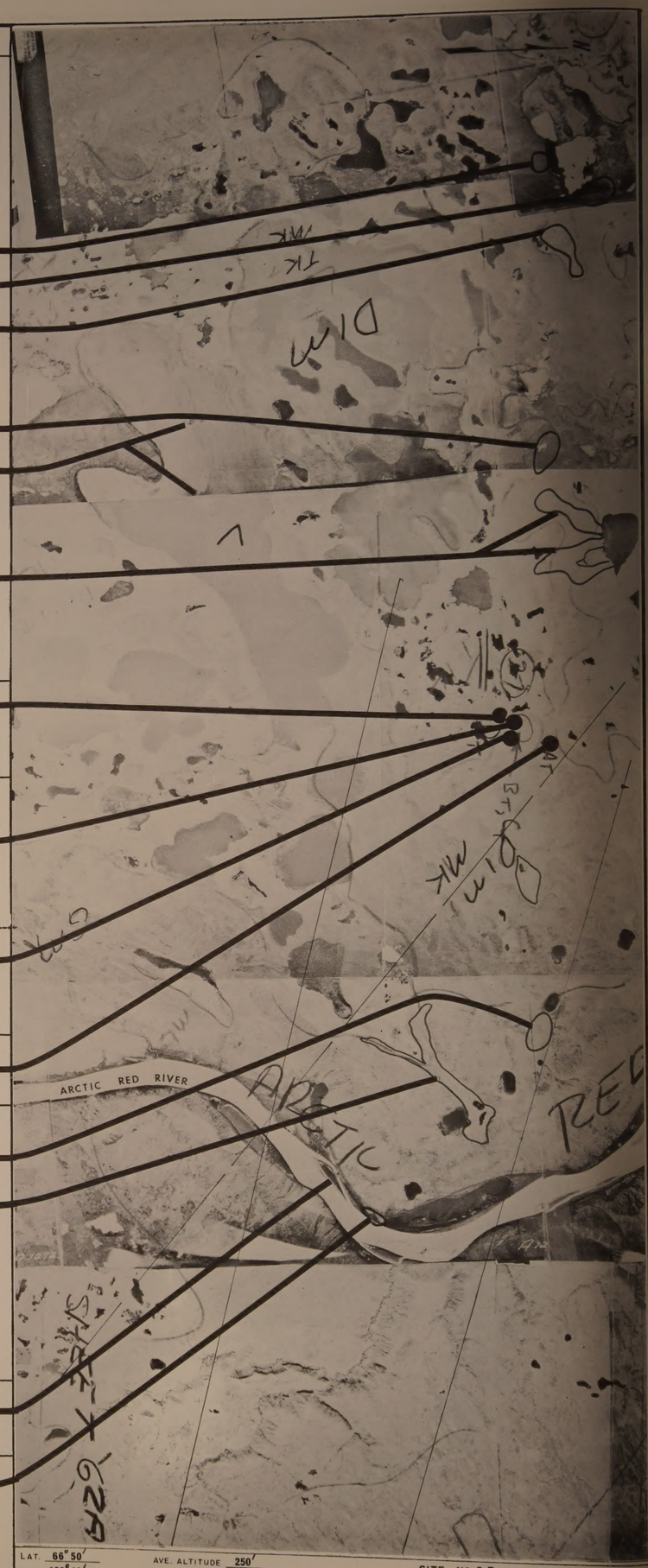
J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
MK	Muskeg, swamp, marsh, bog; includes all unpatterned peatlands
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
L	Lakes: mainly large oriented thaw lakes
DIM	Dead-ice moraine; mainly "ablation" till, often with ice-rich silt or silty clay mantle locally
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand

SEE PLATE No 3 for a comprehensive description of symbols.

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "



LAT. 66°50' LONG 133°10'
AVE. ALTITUDE 250'
MEAN ANNUAL AIR TEMP. 18°F

SITE NO 27 SHEET NO 62 A
PLATE NO. 60

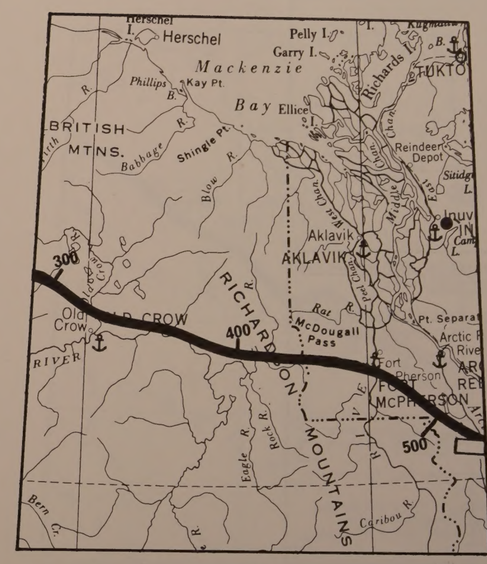
Picture: 1 View looking downstream along Arctic Red River.
Site: 27 E_0

Picture: 2 Left bank of river, 40' in height, gentle slope.
Site: 27 F_0

Picture: 3 Left bank of river, 40' in height, gentle slope.
Site: 27 F_0

Picture: 4 View of sandstone exposure at top of bank shown in Pictures 2 and 3.
Site: 27 F_0

Picture: 5 Closer view of exposure shown in Picture 4.
Site: 27 F_0



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Picture taken in late September, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

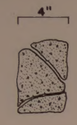
PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 512 TO MILE 525 OFFSET

SUBMITTED	DATE	SITE No.	PLATE No.
R Jewell	Dec/70	27	61
APPROVED	DATE	SHEET No.	
	Dec/70	62A	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ▒ ICE- □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
TK	- Thermokarst plains: pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand
MK	- Muskeg, swamp, marsh, bog; includes all unpatterned peatlands
GM	- Level to gently rolling ground moraine mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
ET	- Gently to moderately sloping water-eroded (sheet erosion) till, often with thin fine sand, silt or silty clay mantle locally
→	Drumlinized and/or fluted surface mainly isolated patches of silt over thin till over bedrock or over fluted bedrock

SEE PLATE No 3 for a comprehensive description of symbols.

This area slopes gently towards Arctic Red River. There are many long narrow string bogs originating in the thermokarst area in the east and traversing west towards the river.

Esker-like ridge

Esker-like ridge

Area of peat plateau and thaw ponds with well defined banks in extensive thermokarst area.

This whole area has extensive thermokarst topography. Area is relatively flat and there are numerous areas of string bog.

Old drainage channel infilling.

This area appears to be actively thawing. There are numerous infill ponds forming in a polygonal pattern.

In this area of thermokarst, the thaw ponds have actively eroding banks on their western side.

Long string bog.

Grass-infill on western side of lake.

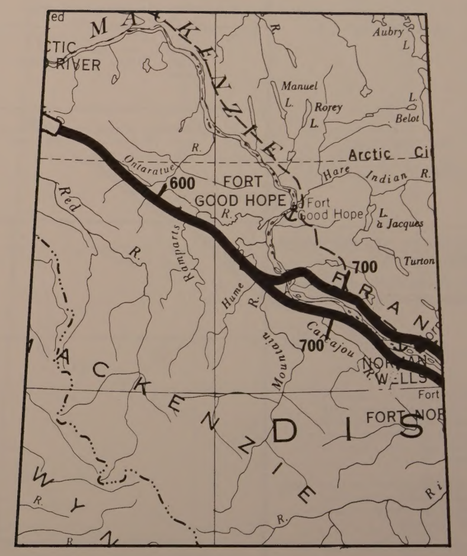
Creek is infilling with grass.

Mosaic Sheet 60 is not included in this presentation. Next five (5) miles beyond the end of this mosaic contains little relief. Vegetation consists of black spruce 10' to 30' in height, some poplars to 30' in height. Old burn areas have heavy growth of lichen. Peat areas evident. Thermokarst lakes are the only relief in the area. Actively eroding thaw banks are evident on the west side of most of the thermokarst lakes.

LAT. 66°50′ LONG. 132°50′ AVE. ALTITUDE 300′ MEAN ANNUAL AIR TEMP. 17°F

SITE NO between 2747 SHEET NO. 61 PLATE NO. 62

NO PICTURES TAKEN



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Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE
	TITLE: Photo Mosaic and Terrain Investigation MILE 523 TO MILE 537
	SUBMITTED: R Jewell — DATE: Dec/70 — SITE No.: 27 & 47 — PLATE No.: 63
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	APPROVED: [illegible] — DATE: Dec/70 — SHEET No.: 61

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED – NO EXCESS ICE

Nbe WELL BONDED – EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL – ▒ ICE – □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
PAL	Palsa-bog terrain; mainly complexly intermingled treed frost-heaved peat mounds and sedge meadows composed of interlayered silt, fine sand, peat, and ground ice with deep peat in hollows in GM or DIM areas
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskeg developed on thick ice-rich organic and inorganic water-laid silt and fine sand
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally

SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
47 A_T	Moderate black spruce and tamarack to 25' in height, willow thickets, labrador tea, lichen. Older trees burned.	0 - ½' PEAT ½' - 9' SILT, and SAND, clayey, (till-like) frozen at 2½', no visible ice, (Nbn) 9' - 16' SHALE, weathered, no visible ice (Nbn)	47 A_T Test hole in well drained ground shown on Picture 1.
47 B_T	Sparse black spruce to 10', grasses, moss very wet. Peat hummocks up to 6' x 3' x 18" high. Heavy black spruce and tamarack to 25' on adjacent string.	0 - 8' PEAT, frozen at 27", ice crystals (Vx) 8' - 15' SILT, organic, clayey, ice crystals, (Vx) 15' - 21' CLAY, silty, no visible ice (Nbn)	47 B_T Test hole in 100' diameter swamp in string bog, shown in Picture 2.
28 C_T	Dense black spruce, occasional birch to 25' in height, small willows, tamarack, labrador tea, berry plants.	0 - 10' SILT, clayey, sandy, frozen at 18", ice lenses and crystals (Vs, Vx) 10' -20½' SHALE, fractured.	28 C_T Test hole at location shown in Picture 3.
28 B_T	Light black spruce to 15' in height. Labrador tea, lichen and moss over peat.	0 - 8' PEAT, frozen below 1½', ice lenses (Vr) 8' - 11' SILT, sandy, 10% ice, in in lenses (Vr) 11' - 16' SAND and GRAVEL, silty. (till-like) 16' - 21' SHALE, weathered.	28 B_T Test hole in small thaw basin in TK area. Picture 4 shows test site looking north to shallow infilling thaw pond. Probing indicated frost at 30" depth in ponds.
28 A_T	Sparse black spruce to 10' in height and labrador tea. Peat mounds 4' to 6' x 3' and approximately 18" high covered with lichen.	0 - 10' PEAT, frozen at 14", ice crystals (Nbe) 10' - 15' SILT, clayey, 5% ice 15' - 19' SILT, SAND, and GRAVEL. (till-like), no visible ice (Nbn) 19' - 20½' SHALE, layered.	28 A_T Test hole in old burn of TK thaw ponds area.
			28 D_0 In string bog. Black spruce on strings from 6' to 15' in height. In swamp, grass, tussocks and labrador tea were encountered in the very wet conditions. Picture 6 shows general area investigated. Frost was encountered at 24 inches under water in the swamp and at 18 " in the slightly better drained area covered by trees.
47 C_T	Old burn area, sparse black spruce, peat hummocks up to 10' x 3' x 18" high, lichen and labrador tea. Numerous TK thaw ponds to 25' diam. in the vicinity and heavy black spruce and tamarack to 25' in height surround old burn.	0 - 1' ORGANIC 1' - 10' SILT, clayey, sandy, (till-like) ice crystals (Vx) 10' - 16' SHALE, laminated, BEDROCK	47 C_T Test hole in shallow depression shown in Picture 5.
			Seismic cut line.
47 D_T	Heavy black spruce tamarack to 25' in height, peat mounds up to 6' x 3' x 18" high. Willow thickets regrowth on cut line.	0 - 15' SILT, sandy, clayey, (till-like) frozen at 1½', 30% ice in lenses to 6' (Vr), sandier, no visible ice (Nbn) below 6'. 15' - 16' SHALE, grey, no visible ice.	47 D_T Test hole on seismic cut line in better drained ground, shown in Picture 7.
47 E_T	Hummocky ground, peat mounds up to 5' x 2' x 18" high. Labrador tea, lichen and moss over peat.	0 - 2½' PEAT, frozen at 1½', no visible ice (Nbn) 2½' - 10' SILT, sandy, clayey, (till-like) few ice crystals (Vx) 10' - 15' SHALE, weathered, few ice crystals (Vx)	47 E_T Test hole in muskeg depression. Picture 8 shows test site and looks north to infilling TK thaw pond. Picture 9 shows surface vegetation details.
47 F_T	Heavy black spruce to 10' and willows to 4' in height	0 - ½' ORGANIC ½' - 10' SILT, clayey, sandy, (till-like) frozen at 1 ', 40% ice lenses ((Vr) 10' - 15' SHALE, grey, weathered	47 F_T Test hole in area shown in Picture 10.
			Seismic cut line.
			28 E_0 In "tapioca" pattern on mosaic, TK area. Picture 11 shows general area including seismic lines and location of test pit. Picture 12 shows test pit in area of black spruce and Labrador tea shrubs. The profile encountered was lichen over peat. Frost depth was 18".
			Seismic cut line.
			Plateau.

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

LAT. 66°35' LONG. 132°00'

AVE. ALTITUDE 450'

MEAN ANNUAL AIR TEMP. 19°F

SITE NO. 28 & 47 SHEET NO. 59

PLATE NO. 64

Picture: 1 Test hole site

Site: 47 A_T

Picture: 2 Test hole site

Site: 47 B_T

Picture: 3 Test hole site

Site: 28 C_T

Picture: 4 Test hole site

Site: 28 B_T

Picture: 5 Looking north across test hole site

Site: 47 C_T

Picture: 6 String bog showing surface vegetation.

Site: 28 D_0

Picture: 7 Test hole site on seismic cut line.

Site: 47 D_T

Picture: 8 View across test hole site to infilling thermokarst pond.

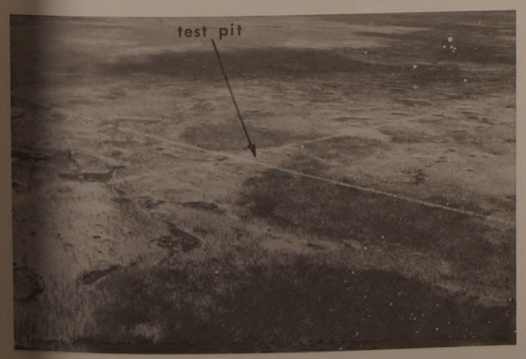
Site: 47 E_T

Picture: 9 Close-up showing vegetation at test hole site.

Site: 47 E_T

Picture: 10 Test hole site.

Site: 47 F_T

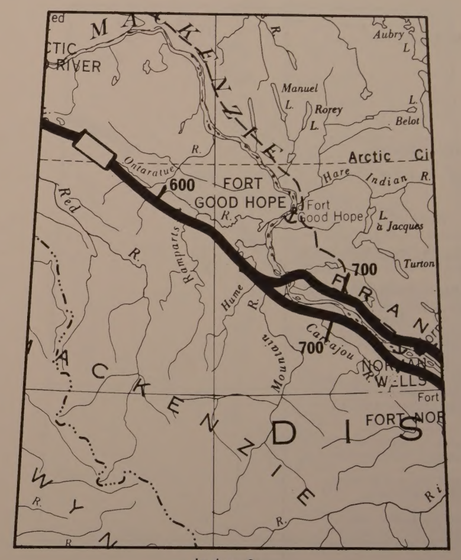


Picture: 11 View looking east from 500' above ground of area with "tapioca-like" pattern on mosaic.

Site: 28 E_0

Picture: 12 Test pit excavated at position shown on Picture 11 near intersection of seismic cut lines.

Site: 28 E_0



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Pictures taken in late September, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE
	TITLE: Photo Mosaic and Terrain Investigation MILE 555 TO MILE 570
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: L Jewell DATE: Dec/70 SITE No.: 47&28 PLATE No.: 65
	APPROVED: Cudpen DATE: Dec/70 SHEET No.: 59

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
				Mounds 2 to 3' in height in old ponds.
				Treed mound 10' in height, 40' in diameter eroding away on south and west sides. Mound surrounded by water.
				Mounds 3 to 5' in height cover almost entire area.
				Beaded drainage along creek.
	48 F_T	Dense, black spruce to 20', occasional birch, willow, labrador tea, hummocky ground, peat mounds to 10' x 3' x 18" high. Lichen and moss over peat.	0 - ½' ORGANIC ½' - 2½' SILT and CLAY, frozen at 1½' 2½' - 3' PEAT 3' - 7' SILT and CLAY, ice lenses (Vr) 7' - 20' SILT, clayey, no visible ice, (Nbn); below 15', (till-like), ice lenses (Vr)	48 F_T Test hole in location shown in Picture 1. Picture 2 is closer view of surface vegetation.
				No evidence of deterioration in bluffs along beaded drainage path. Largely grass infilling with numerous beaver dams across stream.
	48 C_T	Light, black spruce to 10' labrador tea, lichen, small willows on 150' diameter peat mounds.	0 - 7' PEAT, frozen at 20", 5% ice in lenses and crystals (Vx,Vr) 7' - 25' SILT, clayey, 30% ice, in lenses. (Vr,Vs) 25' - 26' SILT, sandy. (till-like)	48 C_T Test hole located on peat plateau in TK as shown in Picture 3.
	48 D_T	Hummocky ground, sparse pockets of black spruce to 15', lichen, labrador tea, occasional small willows.	0 - 7' PEAT, frozen at 22", no visible ice (Nbn) 7' - 25' SILT, clayey, ice lenses (Vr) 25' - 26' SILT, clayey, sandy. (till-like)	48 D_T Test hole located in muskeg filled depression shown in Pictures 4 and 5. Site is adjacent to 48 C_T. Area contains numerous small infilling TK thaw ponds where frost was not encountered within 4' of the surface.
	48 B_T	Heavy black spruce, birch and poplar to 30' berry plants, willow thickets.	0 - 10' SAND, silty, frozen at 7', no visible ice (Nbn)	48 B_T Test hole located on crest of esker shown in Picture 6.
				Cleared area below test site, possibly old seismic camp site.
				Heavy black spruce and poplar growth to 40' lining banks.
				Lake is infilling on east and west banks.
				Numerous peat plateaus in area.
				Grass infill in apparently active thaw lakes.
				Beaded drainage pattern.
				Grass-infill in apparently active thaw ponds. Grass islands also evident in extensive thermokarst area.
				Mounds in lakes.

NOTE: Next 15 miles covered on mosaic sheet 59 is extensive thermokarst and ground moraine terrain similar to that found in the eastern corner of this sheet 58.

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED – NO EXCESS ICE

Nbe WELL BONDED – EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL – ▨ ICE – □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by –
J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand
DIM	Dead-ice moraine; mainly "ablation" till, often with ice-rich silt or silty clay
K	Kames; mounds of sand and gravel with minor gravel and silt inclusions
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
BD	Beaded drainage

SEE PLATE No 3 for a comprehensive description of symbols

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

LAT. 66° 30'
LONG. 131° 45'
AVE. ALTITUDE 400'
MEAN ANNUAL AIR TEMP. 19°F

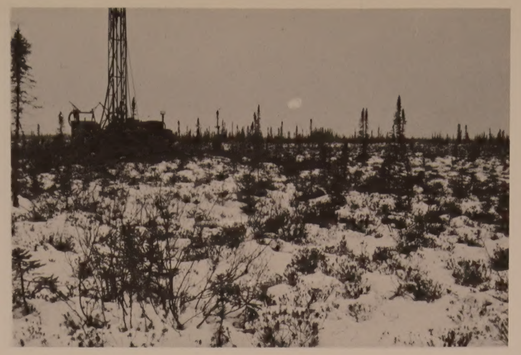
SITE NO. 48 SHEET NO. 58
PLATE NO. 66

Picture: 1 Test hole site.

Site: 48 F_T

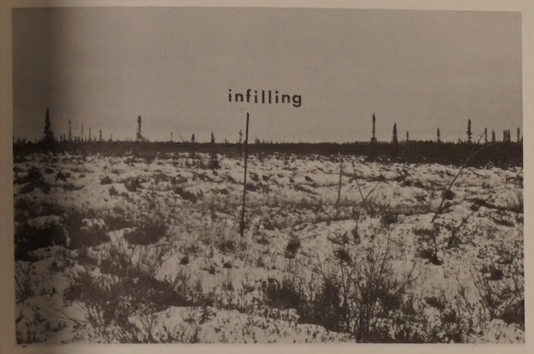
Picture: 2 Close-up of surface vegetation at test hole.

Site: 48 F_T



Picture: 3 Test hole site on peat plateau

Site: 48 C_T



Picture: 4 Infilling thermokarst ponds.

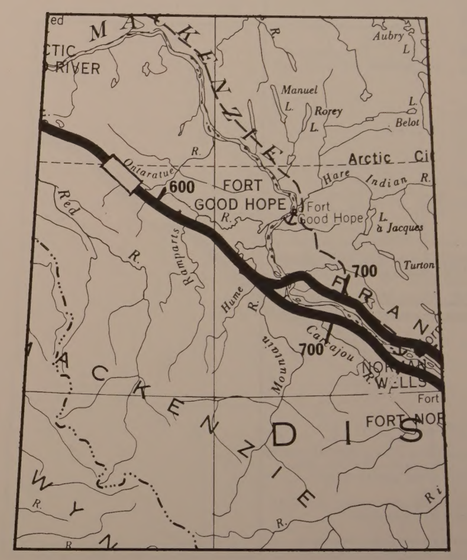
Site: 48 D_T

Picture: 5 Infilling thermokarst pond 15 ft. from test hole.

Site: 48 D_T

Picture: 6 South slope of esker. Test hole is to left of picture on crest.

Site: 48 B_T



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Pictures taken in late September, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON CALGARY REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 569 TO MILE 583

SUBMITTED	DATE	SITE No.	PLATE No.
R Jewell	Dec/70	48	67
APPROVED	DATE	SHEET No.	
Ewdpeer	Dec/70	58	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARL ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
AV	Asymmetric valleys
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
E	Esker ridge; mainly variably bedded sand with minor gravel and silt inclusions
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand
DIM	Dead-ice moraine; mainly "ablation" till, often with ice-rich silt or silty clay

SEE PLATE No 3 for a comprehensive description of symbols.

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

Lake has low banks lined with tilted trees and is infilling with grass.

Heavy spruce growth to 40' line both banks to 1000' from creek, along entire route.

Cover is peat to 3' with prolific moss and lichen growth. Area is very wet. Permafrost encountered 3' below ground surface.

Treed island.

Raised ridge 10' above pond.

Creek has well-defined banks in this area.

Ponds are well-defined and infilling.

Severe burn area.

Some slumping evident on banks in this section of stream.

Numerous ponds and streams.

Area marked "Ice lake" on mosaic appears to be a completely grass infilled thermokarst lake.

Small stream is infilling with grass.

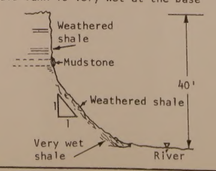
Extensive burn on ridge.

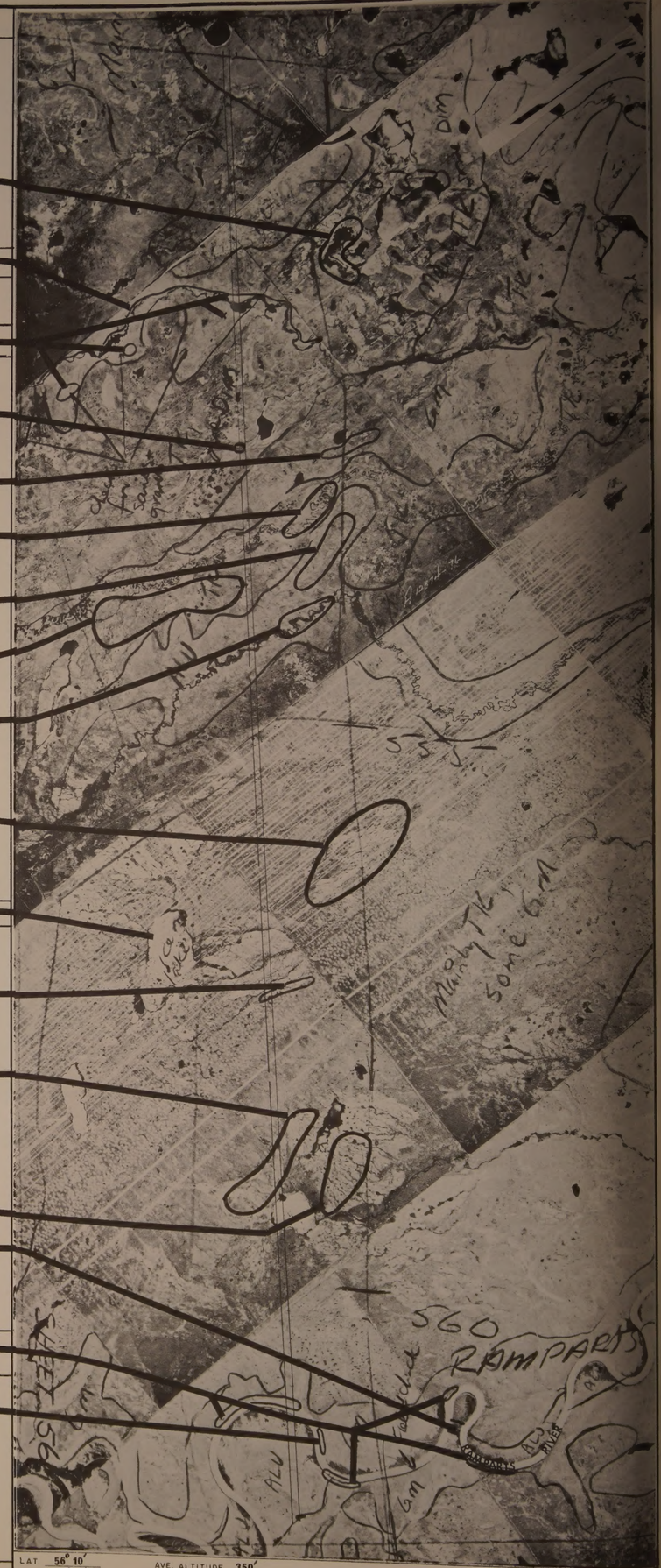
Plateaus and ponds are well-defined.

Active river flood plain.

A_0 Picture 1 shows general view of Ramparts River. Extensive erosion on both banks of river, Pictures 2 and 3. Spruce trees to 30' in height are collapsing into river in many areas in conjunction with slides.

B_0 Pictures 4, 5, and 6 show a 40' high bank exposing a 10' vertical face of weathered shale and mudstone. Shale bank is very wet at the base with water flowing to the river.





LAT. 56° 10'
LONG. 130° 45'

AVE. ALTITUDE 350'
MEAN ANNUAL AIR TEMP. 19° F

SITE NO between SHEET NO. 56
48 & 29 PLATE NO. 68

Picture: 1 Ramparts River showing old flood and stream beds.
Site: A_0

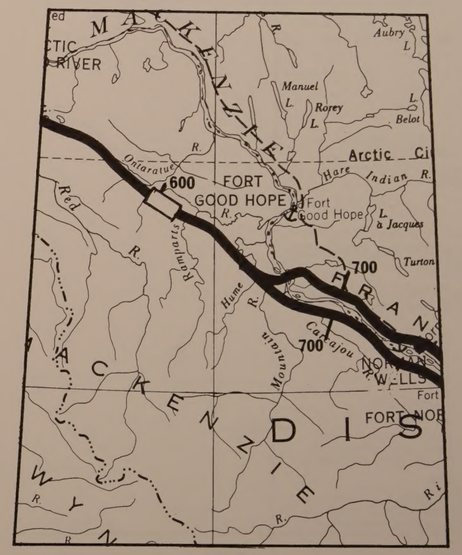
Picture: 2 View of slides on Ramparts River looking downstream.
Site: A_0

Picture: 3 Extensive flow slide on bank of Ramparts River.
Site: A_0

Picture: 4 Shale bank on Ramparts River.
Site: B_0

Picture: 5 Closer view of weathered shale bank in Picture 4 Note mudstone layer.
Site: B_0

Picture: 6 Close-up of mudstone layer in Picture 5
Site: B_0



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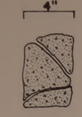
Pictures taken in early October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE
	TITLE: Photo Mosaic and Terrain Investigation MILE 598 TO MILE 613
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: R Jewell DATE: Dec/70 SITE No.: between 48 & 29 PLATE No.: 69
	APPROVED: Sunpeer DATE: Dec/70 SHEET No.: 56

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

Ndn WELL BONDED — NO EXCESS ICE

Nde WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

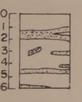
Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ▒ ICE- □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—
J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand
OW	Glacial outwash; mainly sand and gravel with minor silt, often with thin silt mantle

SEE PLATE No 3 for a comprehensive description of symbols

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE
29 D_T	Old burn area; light black spruce and tamarack to 15', peat mounds to 18" in height covered with moss and lichen.	0 - 5' PEAT, frozen at 2', no visible ice 5' - 16' CLAY, silty, 10% ice, in lenses (Vr) 16' - 16½' CLAY, silty, sandy. (till-like) 16½' - 17' SHALE
29 B_T	Sparse black spruce to 10 ft. and tamarack to 20 ft. on hummocky ground surround. test site. Grass only on very wet swampy surface at drill location.	0 - 4½' PEAT, unfrozen 4½' - 9' SILT, clayey 5% ice in lenses Vr 9' - 20' SILT, sandy, (till-like) no visible ice (Nbn) 20' - 21' SHALE, laminated.
29 A_T	Moderate birch, poplar and spruce to 20', 1" moss.	0 - 1" ORGANIC 1" - 8' SAND, fine to medium, unfrozen 8' - 27' SILT, clayey, trace gravel. (till-like), frozen below 15', ice lenses (Vr)
29 C_T	Old burn area, light spruce and tamarack, willow thickets. Hummocky ground with lichen and moss cover over peat mounds.	0 - 4½' PEAT, frozen below 2', no visible ice (Nbn) 4½' - 9½' SILT, sandy, clayey. (till-like) 30% ice, in lenses (Vr) 9½' - 20' SAND and GRAVEL, silty. (till-like), 10% ice, in lenses. (Vr)

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

RECONNAISSANCE OBSERVATION NOTES

Grass-infilling stream beds, few spruce to 10'.

29 D_T Test hole 100' from edge of small infilling TK thaw pond. Pictures 1 and 2 show general site topography and vegetation. Frost depth measured at 5' below level of thaw pond.

29 B_T Test hole adjacent to small thaw pond. Pictures 3 and 4 show vegetation on burnt area around seismic line on which hole was located.

29 A_T Test hole on top of 25' high knoll which is 500' in diameter. Pictures 5 and 6 show different views of the test site.

29 C_T Test hole in depressional area with TK thaw ponds. Hole located 50' from frozen pond shown in Picture 7. Refusal to probing in lake at 4' depth (on ice or till soil?) Picture 8 shows topography and vegetation in area.

Drumlinoidal ridge.

Ridge with grass infilling lakes down centre.

Dense spruce to 40' in height line banks of creek.

Lake is grass-infilling on southern shore.

Lake almost entirely grass infilled.

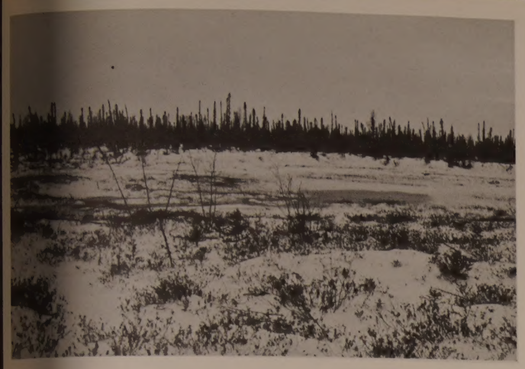
Lake is grass-infilling on NE bank.

Treed peninsula in lake.

Muskeg with lichen and moss growth. Becomes silty at depth.

LAT. 66° 5'
LONG. 130° 0'
AVE. ALTITUDE 350'
MEAN ANNUAL AIR TEMP. 19°F

SITE NO. 29 SHEET NO. 55
PLATE NO. 70



Picture: 1 Frozen lake 100' west of test hole.

Site: 29 D_T

Picture: 2 View east of test site

Site: 29 D_T

Picture: 3 General vicinity of test site.

Site: 29 B_T

Picture: 4 Looking east along seismic line.

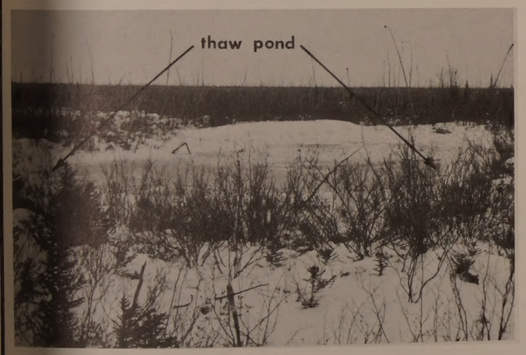
Site: 29 B_T

Picture: 5 Test site from base of knoll.

Site: 29 A_T

Picture: 6 On knoll after clearing.

Site: 29 A_T

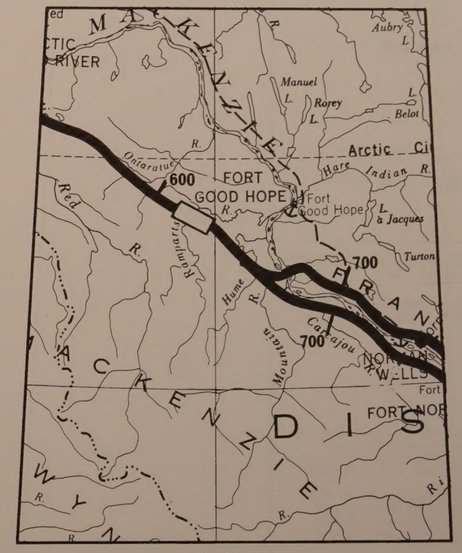


Picture: 7 Frozen thaw pond adjacent to test hole

Site: 29 C_T

Picture: 8 General vicinity of test site.

Site: 29 C_T



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Pictures taken in early October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE				
	TITLE: Photo Mosaic and Terrain Investigation MILE 612 TO MILE 629				
	SUBMITTED: R. Jewell	DATE: Dec/70	SITE No.: 29	PLATE No.: 71
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	APPROVED: Ewbank	DATE:	SHEET No.: 55	

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ICE-

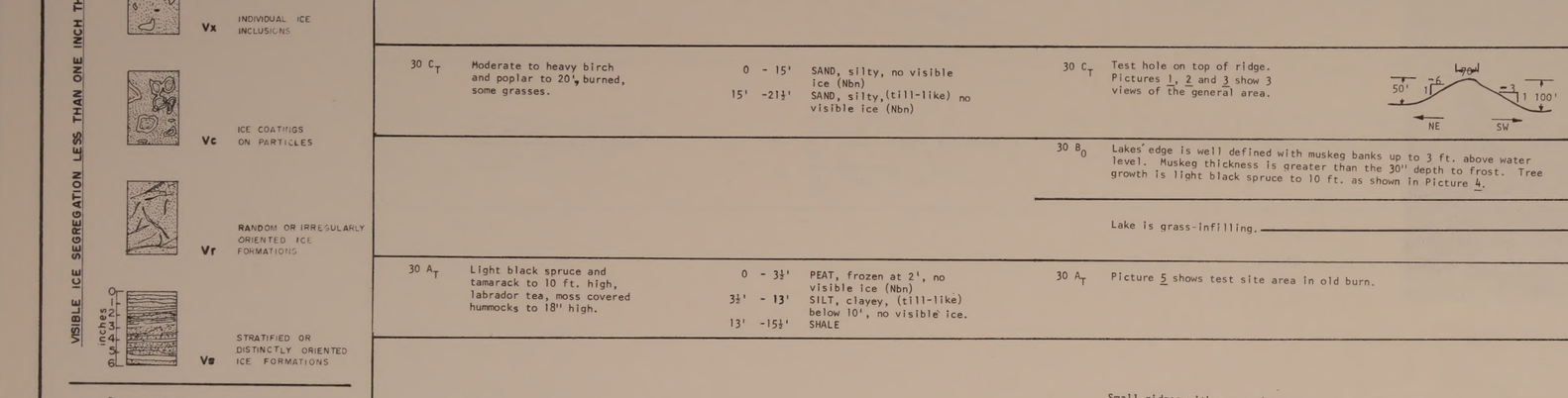
AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
ET	Gently to moderately sloping water-eroded (sheet erosion) till or bedrock plain; mainly thin ice-rich silt or sand mantle over till or bedrock
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand
BD	Beaded drainage
OW	Glacial outwash; mainly sand and gravel with minor silt, often with thin silt mantle

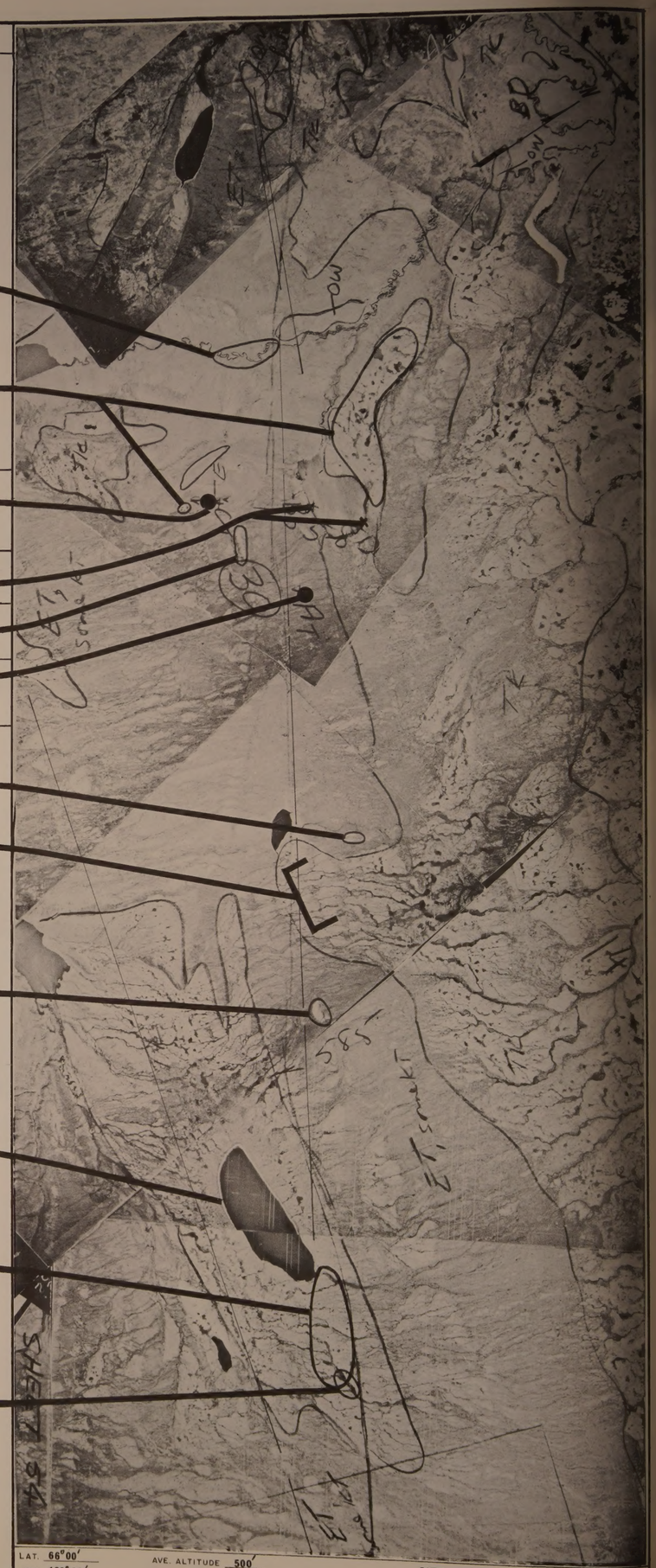
SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
			Tilted spruce in old burn, line creek bank.
			Lakes are grass-infilling on all sides.
30 C_T	Moderate to heavy birch and poplar to 20', burned, some grasses.	0 - 15' SAND, silty, no visible ice (Nbn) 15' -21½' SAND, silty, (till-like) no visible ice (Nbn)	30 C_T Test hole on top of ridge. Pictures 1, 2 and 3 show 3 views of the general area.
			30 B_0 Lakes' edge is well defined with muskeg banks up to 3 ft. above water level. Muskeg thickness is greater than the 30" depth to frost. Tree growth is light black spruce to 10 ft. as shown in Picture 4.
			Lake is grass-infilling.
30 A_T	Light black spruce and tamarack to 10 ft. high, labrador tea, moss covered hummocks to 18" high.	0 - 3½' PEAT, frozen at 2', no visible ice (Nbn) 3½' - 13' SILT, clayey, (till-like) below 10', no visible ice. 13' -15½' SHALE	30 A_T Picture 5 shows test site area in old burn.
			Small ridges with spruce between ponds.
			Strings of trees line water courses.
			Severe burn area.
			Extensive grass-infill all around lake.
			Extensive area of alternate treed mounds and thaw ponds (some infilling).
			Water course is grass-infilling.



NOTE: Tree Population

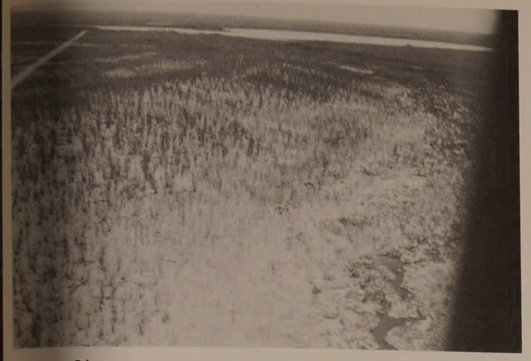
Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "



LAT. 66°00'
LONG 130°00'

AVE. ALTITUDE 500'
MEAN ANNUAL AIR TEMP. 19°F

SITE NO. 30 SHEET NO. 54
PLATE NO. 72



Picture: 1 Looking north east along west side of moraine ridge.

Site: 30 C_T

Picture: 2 Looking north east from ridge along seismic line.

Site: 30 C_T

Picture: 3 Looking west toward another ridge.

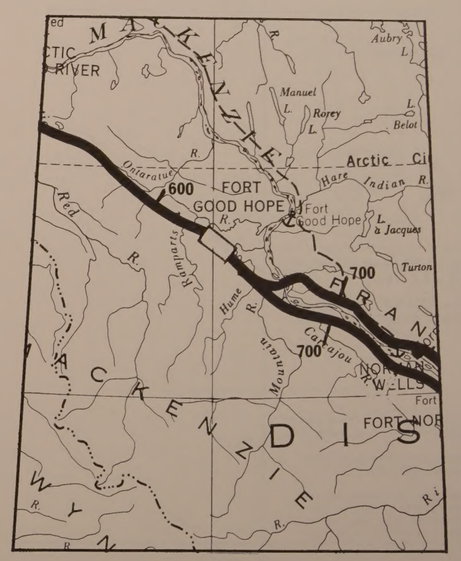
Site: 30 C_T

Picture: 4 View of shoreline of lake.

Site: 30 B_0

Picture: 5 General view of test site.

Site: 30 A_T



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Pictures taken in early October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE		
	TITLE: Photo Mosaic and Terrain Investigation MILE 628 TO MILE 641		
	SUBMITTED: R Jewell	DATE: Dec/70	SITE No.: 30
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	APPROVED: Ewlpeer	DATE: Dec 17/70	SHEET No.: 54
			PLATE No.: 73

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Ndn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

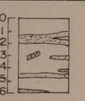
Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ▨ ICE- □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL — ABBREVIATED DESCRIPTION OF TERRAIN

FFP - "Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel

MK - Muskeg, swamp, marsh, bog; includes all unpatterned peatlands

ET - Gently to moderately sloping water-eroded (sheet erosion) till or bedrock plain; mainly thin ice-rich silt or sand mantle over till or bedrock

SEE PLATE No 3 for a comprehensive description of symbols

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

Entire area is extensive burn.

Gravel visible on old flood plain.

Numerous old flood plains at various levels. Spruce trees to 40' line present banks.

Lakes are grass-infilling on all sides.

Numerous treed islands in this area.

Large grass-infill.

Treed island, spruce to 15'.

Grass island.

Lake is grass-infilling on east side.

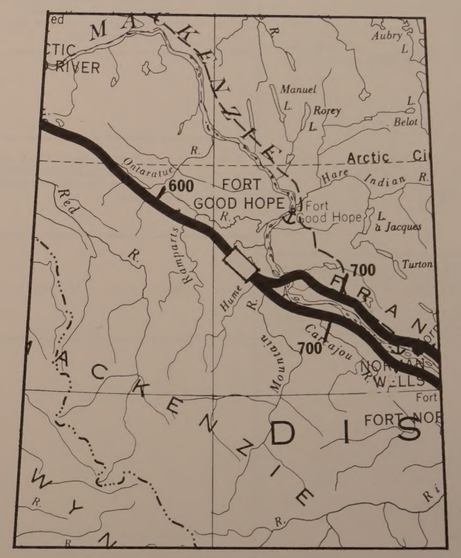
Dense spruce growth on FFP to 40'. Area is old burn and trees have regrown.

LAT. 65°50'
LONG 129°30'

AVE. ALTITUDE 450'
MEAN ANNUAL AIR TEMP. 19°F.

SITE NO. 30 SHEET NO. 53
PLATE NO. 74

NO PICTURES TAKEN



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Pictures taken in late August, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: **MACKENZIE VALLEY PIPELINE** TITLE: Photo Mosaic and Terrain Investigation MILE 641 TO MILE 654
CLIENT: **MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED**	SUBMITTED: L Jewell — DATE: Dec/70 — SITE No.: 30 — PLATE No.: 75 APPROVED: Eur Speer — DATE: Dec/70 — SHEET No.: 53

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ▨ ICE- □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL — ABBREVIATED DESCRIPTION OF TERRAIN

AFD - Variable-textured alluvial fans; mainly thin silt over sand and gravel with major textural variations often inferrable from local geomorphic (depositional) setting

GLB - Thick glacial-lake materials; mainly ice-rich silt and fine sand with minor clay

MK - Muskeg, swamp, marsh, bog; includes all unpatterned peatlands

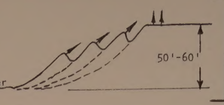
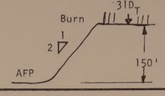
FFP - "Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel

AFP - Active flood plain; mainly exposed sand, gravel and cobbles with boulders locally

OW - Glacial outwash; mainly sand and gravel with minor silt, often with thin silt mantle

SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE
31 B_T	Exposed sand and gravel deposits.	0 - 3' GRAVEL, sandy, unfrozen
31 E_T	On seismic line. Dense poplar and birch to 30'. Edge of adjacent meander channel is swampy and unfrozen.	0 - 8' SAND, silty, frozen at 4' 8' - 15' SILT, sandy, (till-like) loosely frozen (Nf)
31 D_T	Old burn area, level; dense, dead black spruce to 10'; moss, grass under 12" snow cover	0 - 4' SILT, sandy, frozen at 18" no visible ice 4' - 15½' SAND, silty, loosely frozen, (Nf) 15½' - 20½' SILT, sandy, ice lenses (Vr)
31 C_T	On poorly drained hummocky ground; labrador tea, willows, and sparse black spruce to 3' high predominate. Moderate black spruce to 15' and tamarack to 25' adjacent to test site.	0 - 8½' PEAT, frozen at 2', ice lenses and crystals (Vr, Vx) 8½' - 21½' SAND, fine, silty, loosely frozen, (Nf)
32 A_T	Old burn area with sparse black spruce to 6' and some tamarack to 15'; labrador tea and willow shrubs.	0 - 6' PEAT, frozen at 19", ice crystals and lenses (Vx, Vr) 6' - 13' SILT, organic, clayey, 35% ice in lenses (Vs) 13' - 20' GRAVEL, sandy, ice inclusions (Vx)
32 B_T	Recent burn in heavy black spruce and tamarack to 20'; gently rolling ground; fire has removed surface vegetation.	0 - 2½" ORGANIC 2½" - 18' SAND, gravelly coarser with depth, frozen at 8', ice crystals, (Vx)
32 C_T	Recent burn in heavy black spruce and tamarack to 20'; hummocky ground; fire has removed surface vegetation.	0 - 5' SILT, sandy, frozen at 3' no visible ice (Nbn) 5' - 13' GRAVEL and SAND, silty, no visible ice.
32 D_T	Dense spruce to 45', small willows.	0 - 2' SILT, grey, unfrozen 2' - 10' GRAVEL, silty, wet, unfrozen

31 A_O	Observation of extensive slide on east bank of river shown in Picture 1. Old slide area aggravated by toe erosion of the bank by river. Slides of lesser magnitude extend for 4 miles downstream. 
31 B_T	Test hole in exposed point bar of active flood plain: Picture 2 - Picture 3 shows sample of sand and gravel.
	Recent slide on active flow channel.
31 E_T	Test hole adjacent to old river channel in meander flood plain: Picture 4. 
31 D_T	Test hole on terrace as shown in Picture 5. Terrace is 150' above present river level.
	100' high steep bank adjacent to FFP
31 C_T	Test hole in poorly drained muskeg swamp area shown in Picture 6.
	Lake is grass infilling where indicated.
	Extensive burn area around lakes.
	Grass infill.
32 A_T	Test hole in swampy area alongside shallow grass infilling pond shown in Picture 7. Pond water level is 3' below surrounding ground level, Frost was not encountered within 5½' below pond. Picture 8 shows ice lensing in sample recovered from test hole.
	Esker-like ridge.
32 B_T	Test hole on site shown in Picture 9, located on terrace approximately 150' above river level.
	Extensive old flow slides.
32 C_T	Test hole on terrace below 32 B_T Picture 10. Both sites are located in same burned-out area.
32 D_T	Test hole on seismic line 150' from river flood channel: Picture 11. Willows to 10' in channel are leaning in direction of floodwaters.
	Field check shows gravel and sand banks along active flood plain
32 E_O	Sand and gravel deposits in Mountain River as shown in Picture 12. The sand was very fine, brown, with a trace of silt. The large aggregate which ranged from gravel sizes to 6" cobbles was identified as limestones and quartzose siltstones.
	Extensive flow slide above FFP
32 G_O	On extensive river bank slide shown in Picture 13. Picture 14 shows a close-up view of a sand and gravel exposure on the bank. The material varies from medium sand to 6" cobbles. The bank is 80' to 100' high. Boulders and cobbles line the river adjacent to the slide.
	Lakes are grass infilling from all sides.
	Treed island.
	Grass infilling lake.

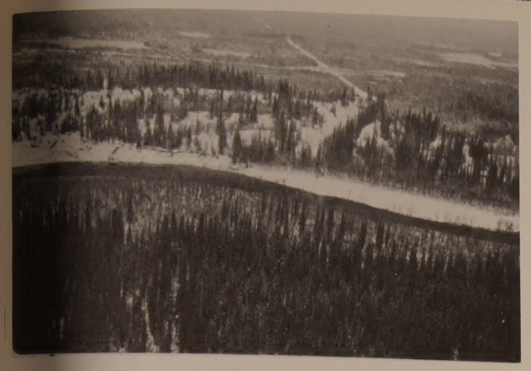
NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

LAT. 65° 45'
LONG. 129° 15'

AVE. ALTITUDE 300'
MEAN ANNUAL AIR TEMP. 20°F

SITE NO 31 & 32 SHEET NO. 52
PLATE NO. 76



Picture: 1
Site: 31 A_0
Extensive sliding on 60' high banks of Hume River.

Picture: 2
Site: 31 B_T
Gravel river bar on Hume River.

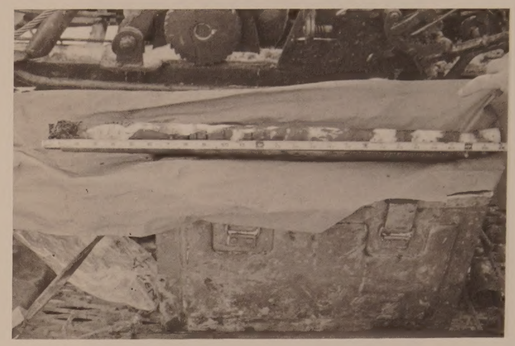
Picture: 3
Site: 31 B_T
Sand and gravel from test hole.

Picture: 4
Site: 31 E_T
Test site on seismic cut line.

Picture: 5
Site: 31 D_T
View of test hole location on terrace.

Picture: 6
Site: 31 C_T
Test hole location.

Picture: 7
Site: 32 A_T
View of frozen pond from test hole location.

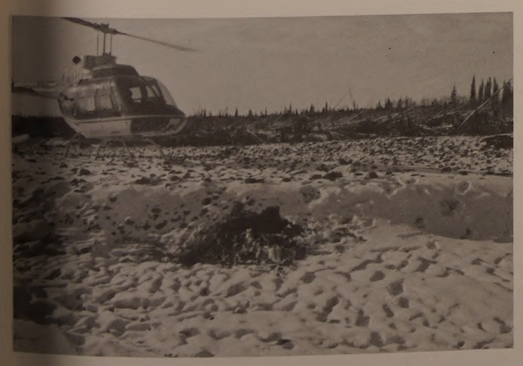


Picture: 8
Site: 32 A_T
Ice lensing in sample from 10' to 12' depth.

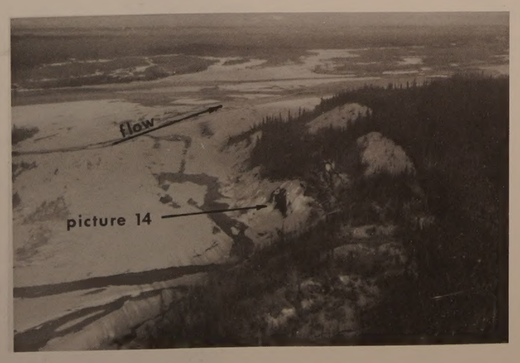
Picture: 9
Site: 32 B_T
Test hole location.

Picture: 10
Site: 32 C_T
Slides along scarp behind test hole location on recently burned ground.

Picture: 11
Site: 32 D_T
Looking upstream along flood channel.

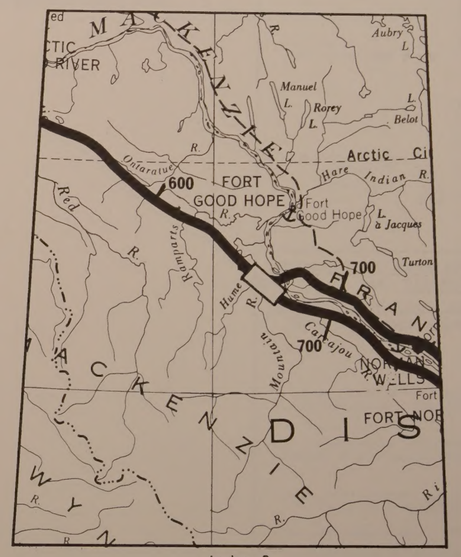


Picture: 12
Site: 32 E_0
Sand and gravel bank on Mountain River.



Picture: 13
Site: 32 G_0
Extensive slide on Mountain River.

Picture: 14
Site: 32 G_0
Material in embankment at exposure shown in Picture 13.



Index 3

Pictures taken in early October, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

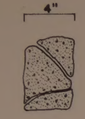
PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 653 TO MILE 669

SUBMITTED	DATE	SITE No.	PLATE No.
R Jewell	Dec/70	31 & 32	77
APPROVED Evelpeer	DATE Dec/70	SHEET No. 52	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

Ndn WELL BONDED — NO EXCESS ICE

Nde WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ICE-

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

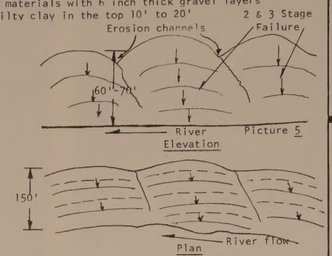
J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
GLB	Thick glacial-lake materials; mainly ice-rich silt and fine sand with minor clay
AFP	Active flood plain; mainly exposed sand, gravel and cobbles with boulders locally
FFP	"Fossil" (i.e., inactive) flood plain; mainly silt over sand and gravel
L	Lakes; mainly large oriented thaw lakes
→	Drumlinized and/or fluted surface; mainly isolated patches of silt over thin till over bedrock or over fluted bedrock

SEE PLATE No 3 for a comprehensive description of symbols.

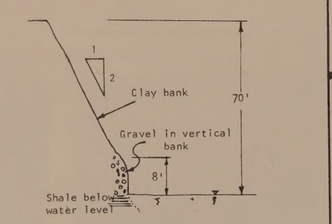
33 A_0 Two and 3 stage slide blocks along length of Mountain River to junction of Mackenzie River. The banks are up to 100' high, averaging about 70'. The slides are in sand and silt materials with 6 inch thick gravel layers in the lower 20' of bank, and silty clay in the top 10' to 20' of the bank.

Picture 1 shows sliding on a typical section of the bank and Pictures 2 to 6 inclusive show various views of one section of the bank.

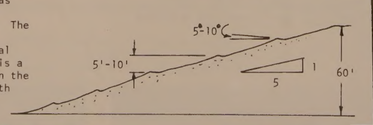


Sketches showing plan and elevation of 2 and 3 stage slide along river bank.

33 B_0 The steep, 70' high bank on the Mountain River shown in Pictures 7, 8 and 9 consisted of clay overlying the 6' to 10' thick layer of gravel and cobbles shown in Picture 10. At river level was a strata of soft shale, (sketched), overlain by a deposit of gravel and cobbles as in Picture 11.



33 C_0 Extensive flow sliding has occurred in the 60' high river bank in this area. The overall bank slope is approximately 5 horizontal to 1 vertical and there is a series of benches left on the surface of the slides with spacings as sketched.

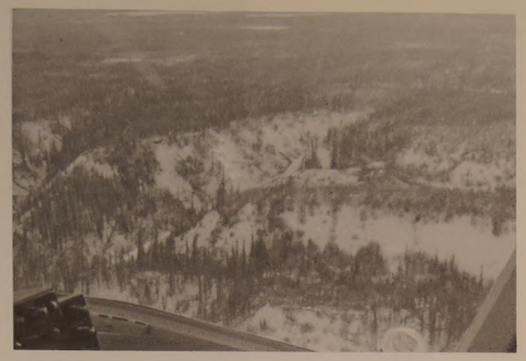


CANADIAN GOVT. COPYRIGHT
DIVISION ENERGY, MINES & RESO

LAT. 65°40′ LONG. 129°00′ AVE. ALTITUDE 300′ MEAN ANNUAL AIR TEMP. 21°F

SITE NO. 33 SHEET NO. 52A PLATE NO. 78

Picture: 1 Sliding along south bank of Mountain River.
Site: 33 A_0



Picture: 2 Block slide along south bank of Mountain River.
Site: 33 A_0

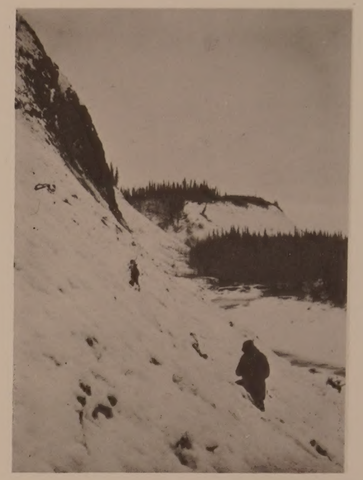
Picture: 3 Block slide on south bank of Mountain River.
Site: 33 A_0

Picture: 4 Different view of block slide shown in Picture 3.
Site: 33 A_0

Picture: 5 Views of block slide shown in Picture 3.
Site: 33 A_0

Picture: 6 View of block slide showing seepage from banks.
Site: 33 A_0

Picture: 7 Steep clay banks adjacent to Mountain River.
Site: 33 B_0

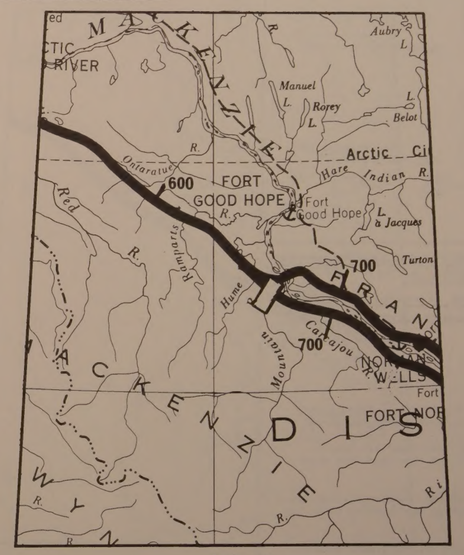


Picture: 8
Clay bank as in Picture 7.
Site: 33 B_0

Picture: 9 Steep clay bank above gravel flood plain on south bank of Mountain River.
Site: 33 B_0

Picture: 10 Gravel and cobbles in 8' high vertical bank overlying shale.
Site: 33 B_0

Picture: 11 Gravel and cobbles at river edge.
Site: 33 B_0



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Pictures taken in early October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE				
	TITLE: Photo Mosaic and Terrain Investigation MILE 663 TO MILE 669				
	SUBMITTED: L Jewell	DATE: Dec/70	SITE No.: 33	PLATE No.: 79	
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	APPROVED: Eulpeer	DATE: Dec/70	SHEET No.: 52 A		

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Ndn WELL BONDED – NO EXCESS ICE

Nde WELL BONDED – EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL – ICE –

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by–

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel
GLB	Thick glacial-lake materials; mainly ice-rich silt and fine sand with minor clay
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
AFD	Variable-textured alluvial fians; mainly thin silt over sand and gravel with major textural variations often inferrable from local geomorphic) depositional) setting
→	Drumlinized and/or fluted surface; mainly isolated patches of silt over thin till over bedrock or over fluted bedrock

SEE PLATE No 3 for a comprehensive description of symbols.

33 A_0 Field observation of large slide. Picture 1 indicates further slides downstream.

Rock dips to North East.

Gas pipeline test loop site shown in Picture 2.

Grass-infilling old river flood channel.

C_0 Sliding on the left bank of Carcajou River as shown in Picture 3 is being aggravated by undercutting of the toe by river erosion. The lower section of the bank is weathered shale which is overlain by sandy silt. Picture 4 is a close-up view of a recent slide in sandy silt in the upper section of this riverbank.

D_0 Picture 5 shows recent sliding occurring in an unstable section of the left bank of the Carcajou River.

E_0 Slumping at the top of a 120' high, vertical, weathered shale bank as shown in Pictures 6 and 7.

F_0 Picture 8 shows a 30' high near vertical shale exposure on the 60' high right bank of the Carcajou River. The shale shown in Picture 9 is overlain by 30' of silty clay in which numerous flow slides have occurred.

Clean sand in old flood plain.

Stable shale banks to 60'. Occasional sandstone boulders to 2'.

60' high steep banks of weathered shale above FFP.

Lake infilling with grass from east.

Slumping of 40' high bank.

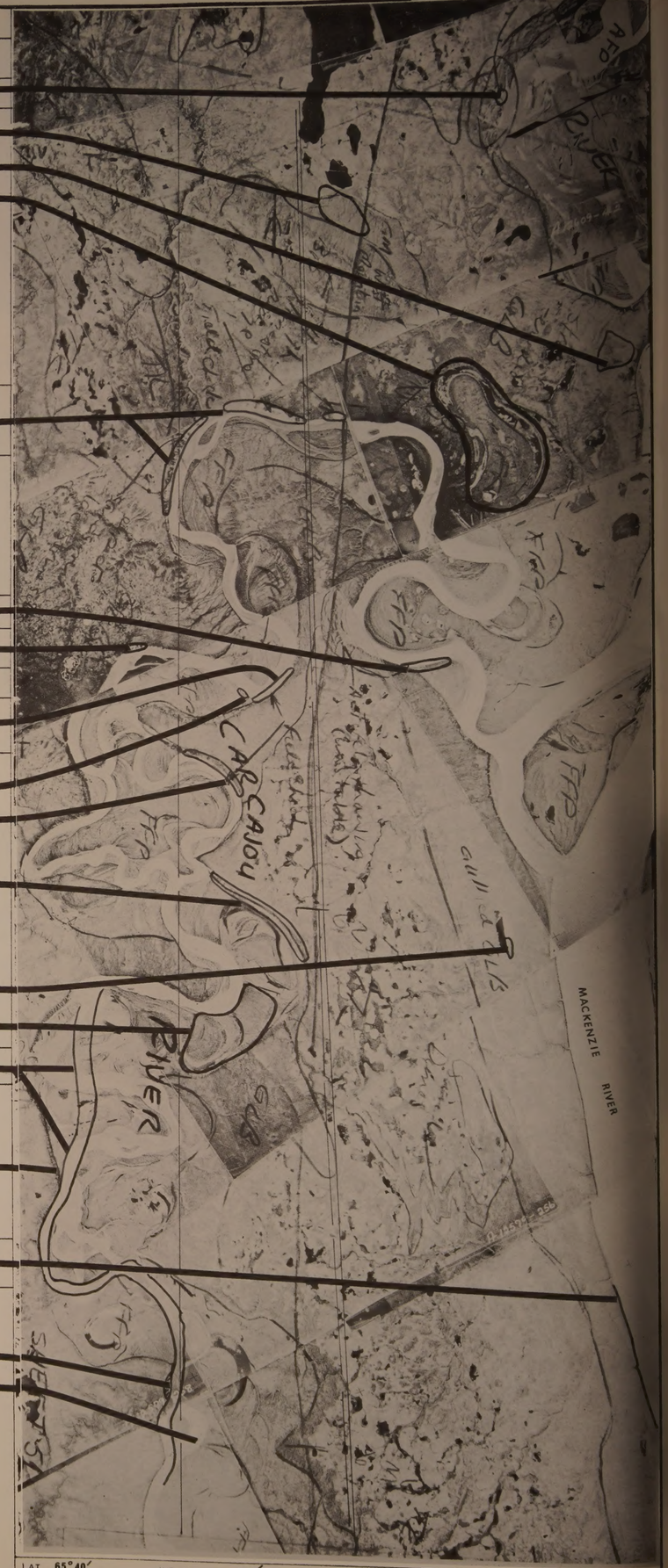
River has changed its course as sketched, since mosaic photography.

50' high stable banks.

G_0 100' high steep banks of weathered shale. A close-up of the exposed shale is shown in Picture 10.

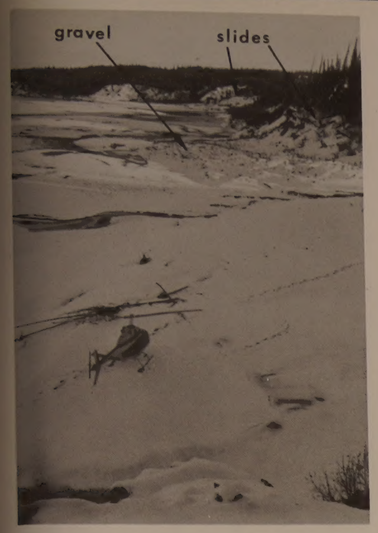
Flow slide on 60' high bank.

Old river channel 3' above existing water level.



LAT. 65°40′ LONG. 128°30′ AVE. ALTITUDE 450′ MEAN ANNUAL AIR TEMP. 20°F

SITE NO. 33 SHEET NO. 51 PLATE NO. 80



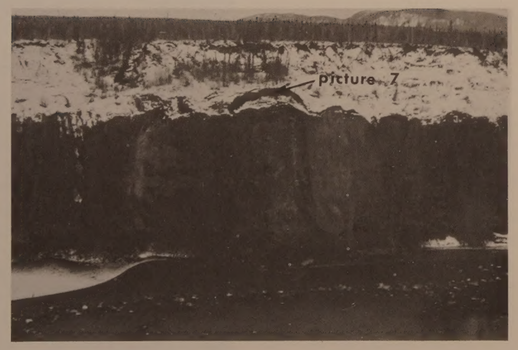
Picture: 1 From face of slide looking south east along bank. Note further slides and extent of gravel banks in river.
Site: A_0

Picture: 2 Gas pipeline test loop site at Mountain River.
Site: B_0

Picture: 3 Slide on Carcajou River bank. Total bank height approximately 300'.
Site: C_0

Picture: 4 Close-up of slide in sandy silt upper strata shown in Picture 3.
Site: C_0

Picture: 5 Recent slide in 150' high river bank on Carcajou River.
Site: D_0



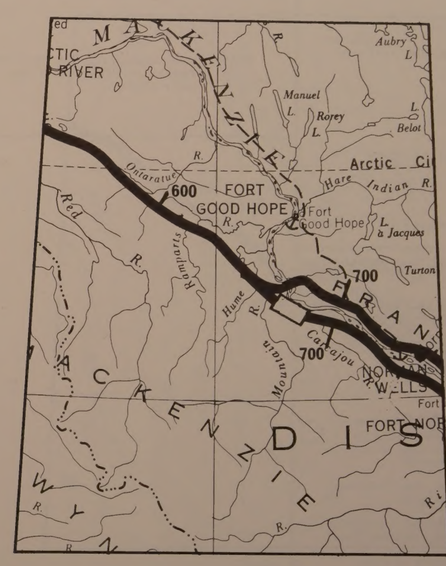
Picture: 6 Slumping in 120' high bank.
Site: E_0

Picture: 8 View of 60' high right bank of Carcajou River.
Site: F_0

Picture: 9 Close-up of shale in bank in Picture 8.

Picture: 7
Close-up of recent slide shown in Picture 6.
Site: E_0

Picture: 10
Close-up of weathered shale.
Site: G_0



Pictures taken in early October, 1970

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CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

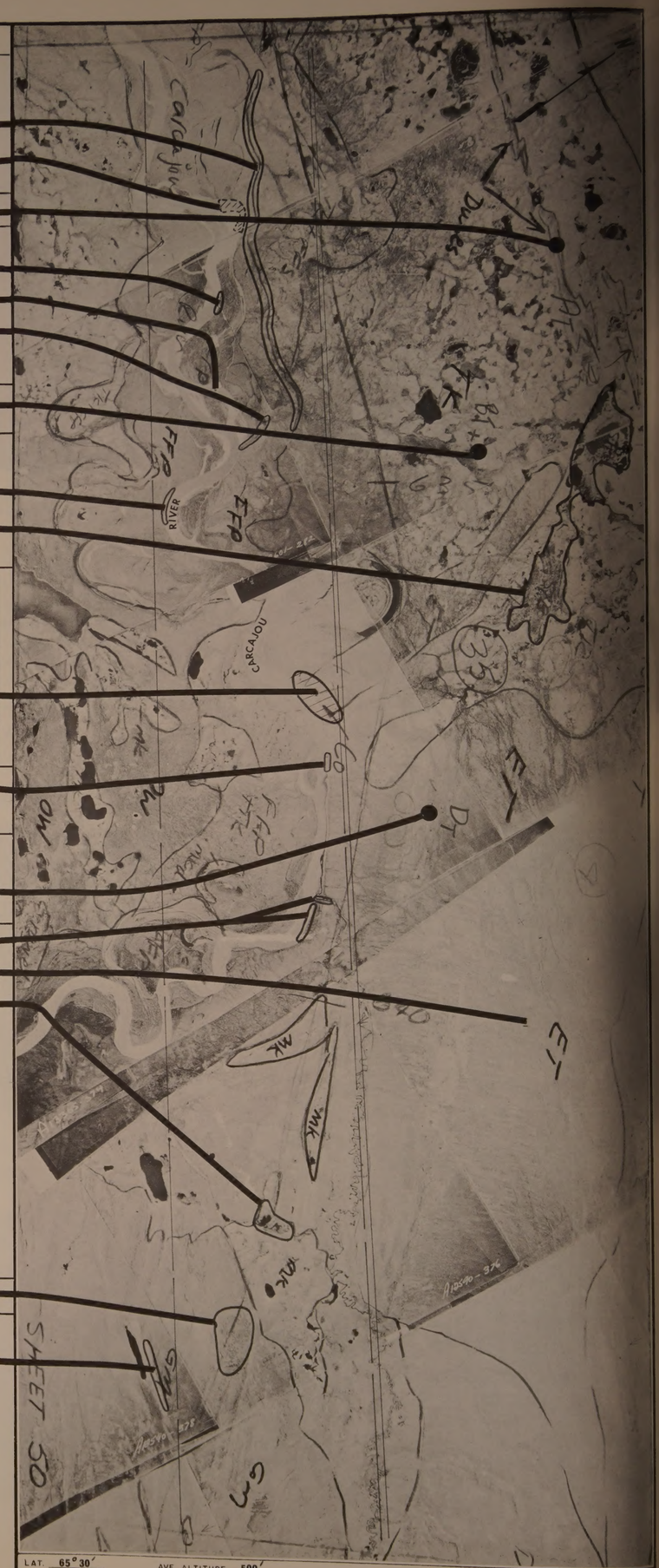
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

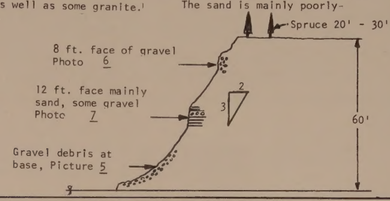
PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 668 TO MILE 682

SUBMITTED	DATE	SITE No.	PLATE No.
R Jewell	Dec/70	between 33 & 35	81
APPROVED	DATE	SHEET No.	
[illegible]	Dec/70	51	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
				Extensive esker-like ridge.
				Inactive flood plain 4' above river level.
	35 A_T	Heavy spruce and birch to 35'; berry plants, no organic cover.	0 - 21' SAND, fine frozen below 5-3/4', no visible ice (Nbn)	35 A_T Test hole on crest of 40' high sand dune. Picture 1.
				River is undercutting bank.
				Flood plain 3' above existing river level.
				Creek has infilled with grass.
	35 B_T	Heavy black spruce and occasional tamarack to 20'; labrador tea, moss.	0 - 7' PEAT, frozen at 2', ice crystals (Vx) 7' -21½' SAND and SILT, no visible ice (Nbn)	35 B_T Test hole located 100' from thaw pond in TK shown in Picture 2. Elevation of site is approx. 3' above thaw pond shown close-up in Picture 3.
				Bank sloughing by undercutting.
				String bog.
				35 C_0 60' high river bank shown in Picture 4 consists mainly of sand and gravel as shown in Pictures 5, 6 and 7. Gravel identified as including sandstone, chert and shale as well as some granite. The sand is mainly poorly-graded greywacke.
				Shale exposed in vertical bank 40' high.
	35 D_T	Heavy black spruce and occasional tamarack to 20'; labrador tea, berry plants.	0 - 4' SILT and CLAY, frozen at 20", ice crystals (Vx) 4' - 13' SAND and GRAVEL, clean, no visible ice (Nbn) 13' - 18' SHALE, weathered.	35 D_T Test hole on sheetwash slope as shown in Picture 8. Picture 9 shows test site.
				Undercut banks on river and creek.
				ET area generally heavily timbered with spruce and tamarack to 40'.
				Grass and muskeg infill.
				Thick spruce outcrop 40' high in area where timber is predominantly birch to 30'.
				Very steep ridges.





VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

- **Nf** POORLY BONDED
- **Nbn** WELL BONDED — NO EXCESS ICE
- **Nde** WELL BONDED — EXCESS ICE
- **Vx** INDIVIDUAL ICE INCLUSIONS
- **Vc** ICE COATINGS ON PARTICLES
- **Vr** RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS
- **Vs** STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

- **ICE & SOIL** ICE WITH SOIL INCLUSIONS
- **ICE** ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—
J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
MK	Muskeg, swamp, marsh, bog; includes all unpatterned peatlands
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel
OW	Glacial outwash; mainly sand and gravel with minor silt, often with thin silt mantle
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs, developed on thick ice-rich organic and inorganic waterlaid silt and fine sand
SB	String bog (ribbed fen); mainly deep peat deposits
ET	Gently to moderately sloping water-eroded (sheet erosion) till or bedrock plain; mainly thin ice-rich silt or sand mantle over till or bedrock

SEE PLATE No 3 for a comprehensive description of symbols.

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

LAT. 65° 30'
LONG 128° 30'
AVE. ALTITUDE 500'
MEAN ANNUAL AIR TEMP. 21°F

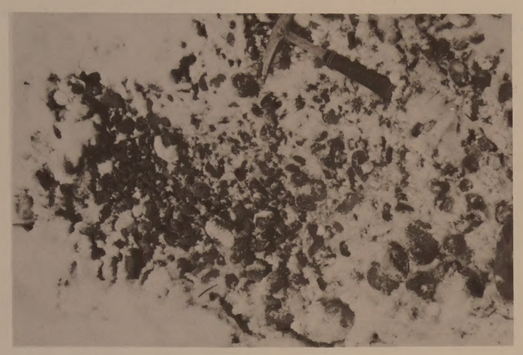
SITE NO. 35 SHEET NO. 50
PLATE NO. 82

Picture: 1
Site: 35 A_T
View looking NE from ridge along seismic cut line adjacent to test hole.

Picture: 2
Site: 35 B_T
From air looking north at site.

Picture: 3
Site: 35 B_T
Looking across lake.

Picture: 4
Site: 35 C_0
Right bank of Carcajou River.



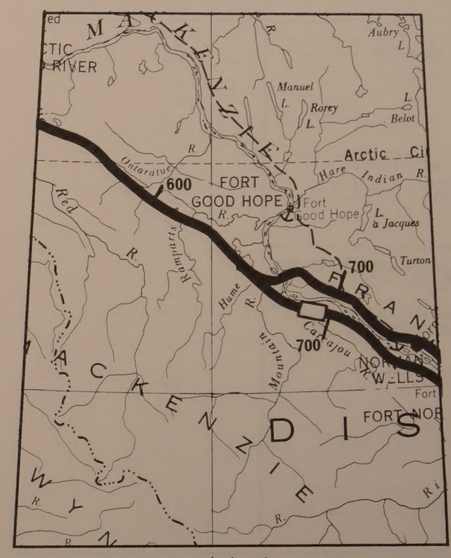
Picture: 5
Site: 35 C_0
Gravel 15' above base of bank.

Picture : 6
Site: 35 C_0
Sand and gravel in vertical face near top of bank.

Picture: 7
Site: 35 C_0
Vertical sand and gravel face 12' high at mid-point of bank.

Picture: 8
Site: 35 D_T
View of test site looking south east.

Picture: 9
Site: 35 D_T
View of test hole site.



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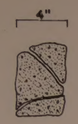
Pictures taken in early October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE TITLE: Photo Mosaic and Terrain Investigation MILE 682 TO MILE 697
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: R Jewell — DATE: Dec/70 — SITE No.: 35 — PLATE No.: 83 APPROVED: Gulpeer — DATE: Dec/70 — SHEET No.: 50

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand.

SEE PLATE No 3 for a comprehensive description of symbols.

Tree growth mainly spruce to 40' over entire area.

Lakes and stream beds are grass-infilling in TK area.

Prominent ridge with few spruce but mainly birch trees.

Grass-infilling creek.

Banks of lake are stable, well defined.

Numerous ingrown old stream beds.

Infilling along west bank.

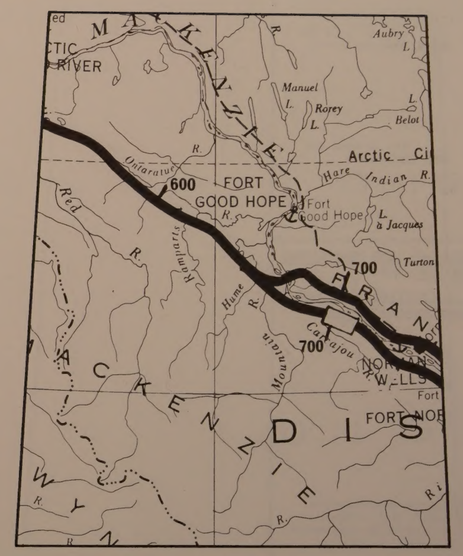
Slight infill all round.

LAT. 65° 20′
LONG. 127° 50′

AVE. ALTITUDE 800′
MEAN ANNUAL AIR TEMP. 22°F

SITE NO. between SHEET NO. 49
35&36 PLATE NO. 84

NO PICTURES TAKEN



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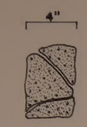
Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE			
	TITLE: Photo Mosaic and Terrain Investigation MILE 697 TO MILE 712			
	SUBMITTED: L Jewell	DATE: Dec/70	SITE No.: between 35 & 36	PLATE No.: 85
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	APPROVED: Carlsen	DATE: Dec/70	SHEET No.: 49	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

Nbn WELL BONDED – NO EXCESS ICE

Nbe WELL BONDED – EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

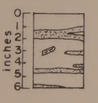
Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ICE-

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by–

J. D. Mollard and Associates Limited

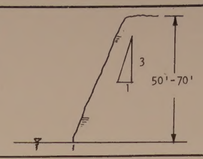
MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand
FFP	"Fossil" (i. e., inactive) flood plain; mainly thin silt over sand and gravel

SEE PLATE No 3 for a comprehensive description of symbols.

Well-drained lake surrounded by tall spruce.

Lake is grass-infilling.

Field check - site of old slides. River has carried away all slide material. Banks appear to be stable with exposure of shale and clay layers.



Grass-infilled stream.

All lakes and streams are grass-infilling in TK area.

Extensive burn area.

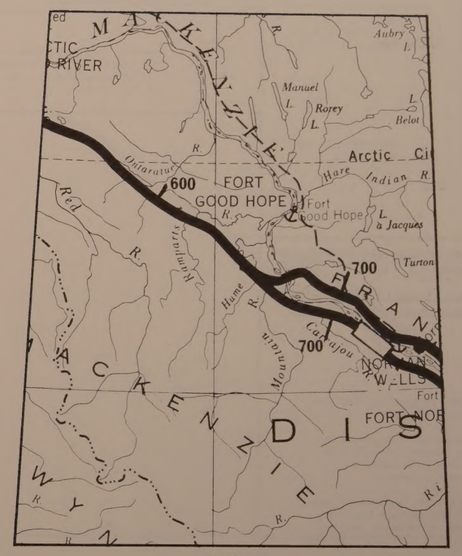
Esker-like ridge.

LAT. 65° 15′
LONG 127° 30′

AVE. ALTITUDE 800′
MEAN ANNUAL AIR TEMP. 22°F

SITE NO between SHEET NO. 48
35 & 36 PLATE NO. 86

NO PICTURES TAKEN



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Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG CLIENT MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	PROJECT MACKENZIE VALLEY PIPELINE TITLE Photo Mosaic and Terrain Investigation MILE 712 TO MILE 727 SUBMITTED L Jewell DATE Dec/70 SITE No. between 35 & 36 PLATE No. 87 APPROVED Curlpeer DATE Dec 1/70 SHEET No. 48

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Ndn WELL BONDED — NO EXCESS ICE

Nde WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

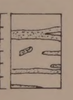
Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ▨ ICE- □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL — ABBREVIATED DESCRIPTION OF TERRAIN

MK - Muskeg, swamp, marsh, bog; includes all unpatterned peatlands

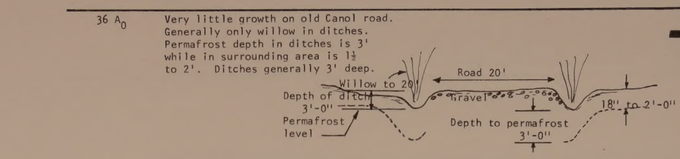
GM - Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally

TK - Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand

E - Esker ridge; mainly variably bedded sand with minor gravel and silt inclusions

SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	REGONNAISSANCE OBSERVATION NOTES
			36 A_0 Very little growth on old Canol road. Generally only willow in ditches. Permafrost depth in ditches is 3' while in surrounding area is 1½ to 2'. Ditches generally 3' deep.
			Grass-infilling lakes.
			Well-defined lakes.
			Creeks are all grass infilled.
			36 E_0 On overgrown roads or firebreaks apparently associated with Canol Camp. Pictures 1 and 2 show general views of the road and Picture 3 shows wheel rutting. Probing indicated permafrost at 3½' below road, 1½' on adjacent ground. Tree cover is mainly black spruce, with some birch, willow and labrador tea.
36 D_T	Heavy birch to 25', and occasional spruce; labrador tea, berry plants.	0 - 5" MOSS and PEAT 5" - 21' SAND, silty, frozen at 15', no visible ice (Nbn).	36 D_T Test hole on morainal ridge approximately 40' high shown in Picture 4. Picture 5 is a close-up of vegetation.
36 C_T	Moderate black spruce to 15'; small willows; labrador tea, lichen and moss on peat mounds.	0 - 5' PEAT, frozen at 18", ice crystals (Vx) 5' - 21' SILT, SAND, CLAY. (till-like), 15% ice in lenses and crystals (Vr,Vx)	36 C_T Test hole in low lying area adjacent to small thaw pond. Pictures 6 and 7 show general views of the site and vegetation.
36 B_T	Moderate to light birch to 30'; occasional spruce and willow; berry plants, labrador tea, lichen.	0 - 3" ORGANIC 3" - 3½' SILT, organic, unfrozen 3½' - 9½' SAND, fine, unfrozen 9½' - 21' CLAY and SILT, shale particles, frozen.	36 B_T Test hole on small ridge adjacent to small creek. Picture 8 shows ground cover at site
			Well-defined lake with light spruce to 30' on banks.
			Heavy spruce growth to 40'.
			Continuous esker-like ridge.
			Lake is grass infilling all round.
			Creek is grass infilling.
			Sand dunes and ridges.
			Well-defined lake banks.



NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

LAT. 65°10'
LONG 127°15'

AVE. ALTITUDE 600'
MEAN ANNUAL AIR TEMP. 21°F

SITE NO. 36 SHEET NO. 47
PLATE NO. 88

Picture: 1 Road near Canol Camp.

Site: 36 E_0

Picture: 2 Road near Canol Camp

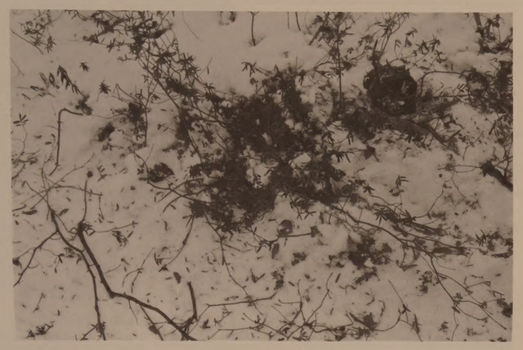
Site: 36 E_0

Picture: 3 Close-up of road alongside lake in Picture 2.

Site: 36 E_0

Picture: 4 Looking north at test hole site on ridge.

Site: 36 D_T



Picture: 5 Close-up of surface vegetation at test site.

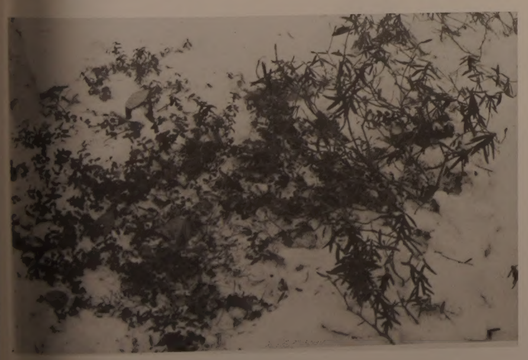
Site: 36 D_T

Picture: 6 View of test hole site.

Site: 36 C_T

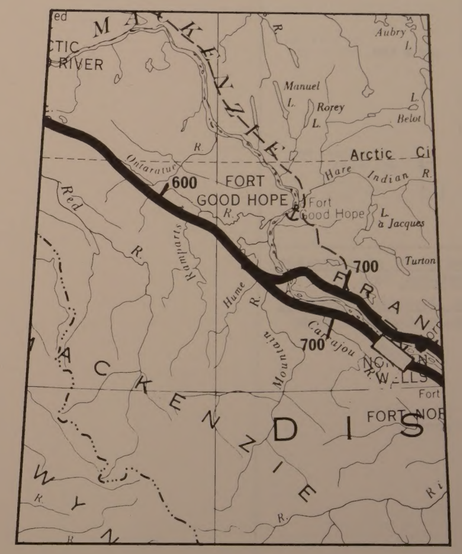
Picture: 7 Close-up of surface vegetation at test hole site.

Site: 36 C_T



Picture: 8 Close-up of surface vegetation at test hole.

Site: 36 B_T



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Pictures taken in early October, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER EDMONTON CALGARY REGINA WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 726 TO MILE 740

SUBMITTED	DATE	SITE No.	PLATE No.
D Jewell	Dec/70	36	89
APPROVED	DATE	SHEET No.	
Ev Speer	Dec/70	47	

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Ndn WELL BONDED — NO EXCESS ICE

Nde WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ICE-

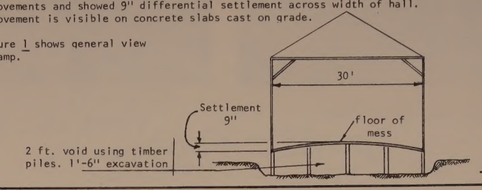
AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

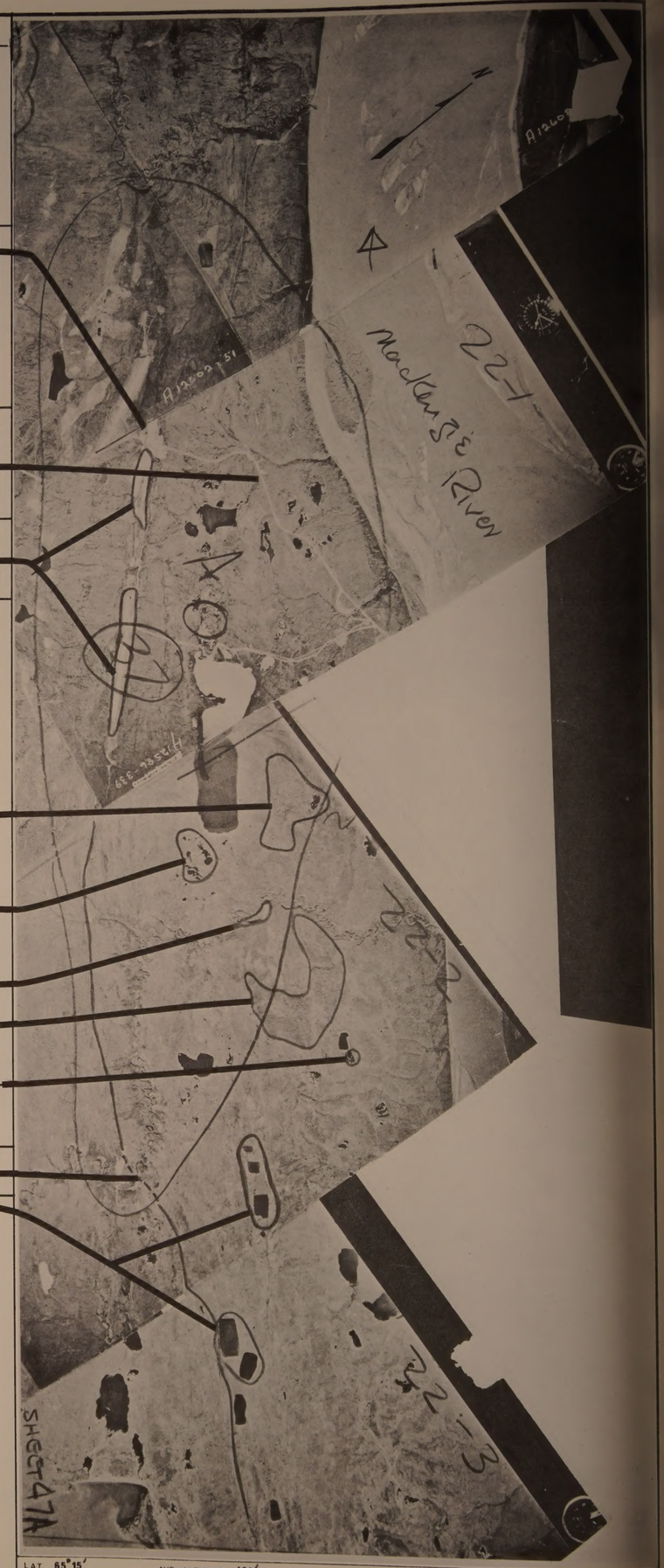
J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN

Mosaic not annotated

SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
37 A_0			Canol Camp. Main mess hall which is 220' x 30' was inspected for signs of movements and showed 9" differential settlement across width of hall. No movement is visible on concrete slabs cast on grade. Picture 1 shows general view of camp. 
			Entire length of roadway ditch is now ingrown with willow and poplar. No serious erosion has occurred. Probing in ditches encountered no permafrost within 4' of surface.
37 B_0			Extensive sand ridge which has been used as a borrow pit. Pictures 2, 3, 4 and 5 give an indication of extent of deposit and type of material. Surface is still 15' to 20' above surrounding area.



Grass infilled TK area.

Lakes are grass-infilling.

Bank 80' - 100' high undercut by stream.

Area of heavy spruce growth to 60'.

Treed island in lake.

Continuous sand ridge with mainly poplar, some spruce growth lining road on top of ridge.

Well-defined lakes.

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

LAT. 65°15'
LONG. 127°00'

AVE. ALTITUDE 400'
MEAN ANNUAL AIR TEMP. 21°F

SITE NO. 37 SHEET NO. 47A
PLATE NO. 90

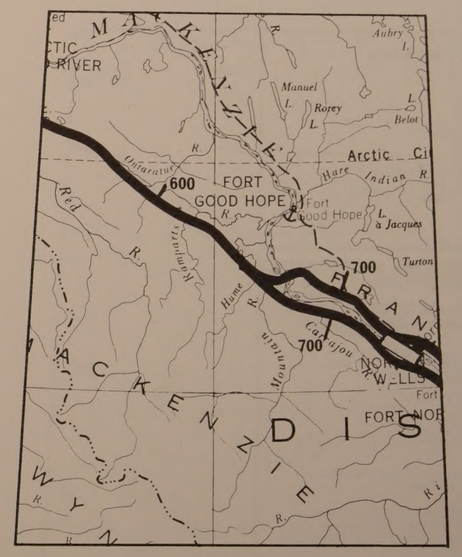
Picture: 1 Abandoned Canol Camp.
Main mess hall and barracks.
Site: 37 A_0

Picture: 2 Sand dune borrow pit from air looking west.
Site: 37 B_0

Picture: 3 Close-up of dune borrow area looking south.
Site: 37 B_0

Picture: 4 Looking north along dune borrow area towards helicopter.
Site: 37 B_0

Picture: 5 Sand exposure on dune.
Site: 37 B_0



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Pictures taken in early October, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER EDMONTON CALGARY REGINA WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 724 TO MILE 740 OFFSET

SUBMITTED	DATE	SITE No.	PLATE No.
R Jewell	Dec/70	37	91
APPROVED	DATE	SHEET No.	
Curlpeer	Dec/70	47A	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE.

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ICE-

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
MK	Muskeg, swamp, marsh bog; includes all unpatterned peatlands
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
L	Lakes; mainly large oriented thaw lakes
→	Drumlinized and/or fluted surface; mainly isolated patches of silt over thin till over bedrock or over fluted bedrock

SEE PLATE No 3 for a comprehensive description of symbols.

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

Muskeg swamps with palsa mounds evident.

Well-defined lake.

Infilled thermokarst area.

Grass infilling and grass islands.

Lake is grass-infilling from west.

Heavy spruce to 40' lining creek banks.

Well-defined lake.

Well-defined lake.

Grass-infilled thermokarst area.

Area of extensive old burn.

Deeply eroded creek lined with heavy spruce to 40'. Entire surrounding area is old burn.

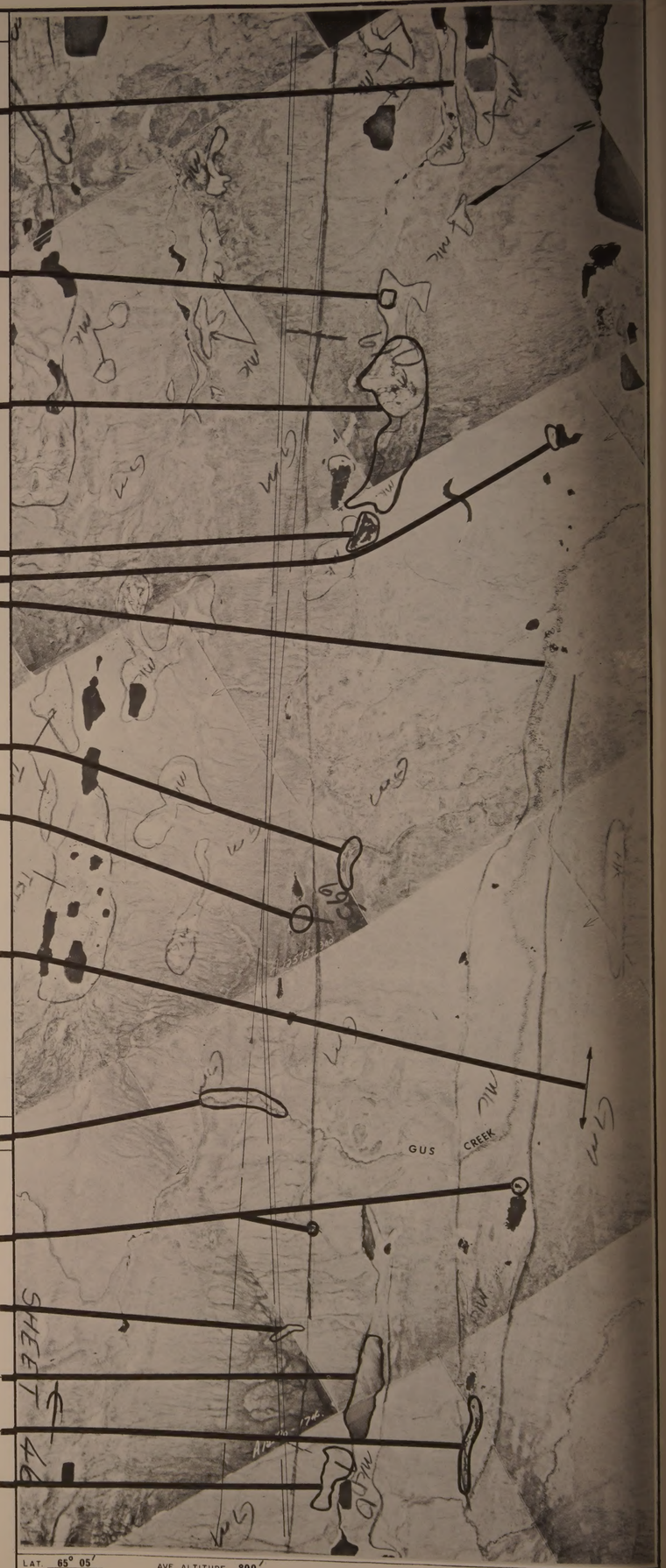
Grass infilling lakes.

Esker-like ridge.

Well-defined lake.

Grass infilled stream and drainage path.

Heavy spruce growth.



LAT. 65° 05'
LONG 126° 45'

AVE. ALTITUDE 800'
MEAN ANNUAL AIR TEMP. 22°F

SITE NO between SHEET NO. 46
37 & 38 PLATE NO. 92

NO PICTURES TAKEN

Index 3

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT **MACKENZIE VALLEY PIPELINE**				
	TITLE Photo Mosaic and Terrain Investigation MILE 754 TO MILE 769				
	SUBMITTED R Jewell	DATE Dec 70	SITE No. between 37 & 38	PLATE No. 95	
CLIENT **MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED**	APPROVED Ewlpon	DATE Dec 70	SHEET No. 45		

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Ndn WELL BONDED — NO EXCESS ICE

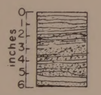
Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

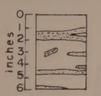
Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS



Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ▒ ICE- □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
MK	Muskeg, swamp, marsh, bog; includes all unpatterned peatlands
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
TK	Thermokarst plain; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand
	Drumlinized and/or fluted surface; mainly isolated patches of silt over thin till over bedrock or over fluted bedrock

SEE PLATE No 3 for a comprehensive description of symbols

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

Grass infilled stream and drainage path.

Dark lines represent heavy spruce ribbons to 50' in height surrounded by smaller spruce and tamarack.

Lake is grass-infilling all round.

Muskeg and grass-infill.

Well-defined lake.

Grass-infilling stream.

Slater River has 50' high vertical shale banks. Heavy spruce to 60' in height line top of banks.

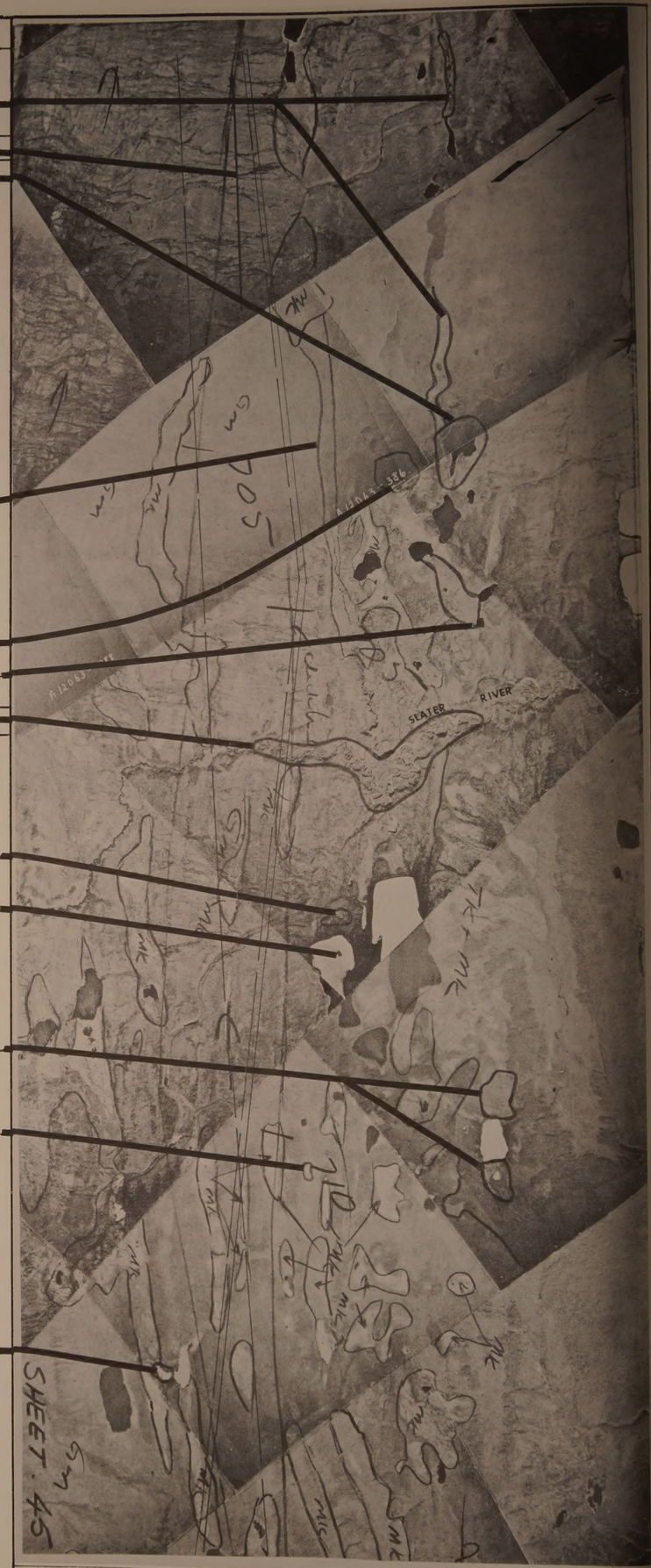
Dune-like ridge.

Treed island.

Muskeg areas.

Dune-like ridges.

Grass infilling.

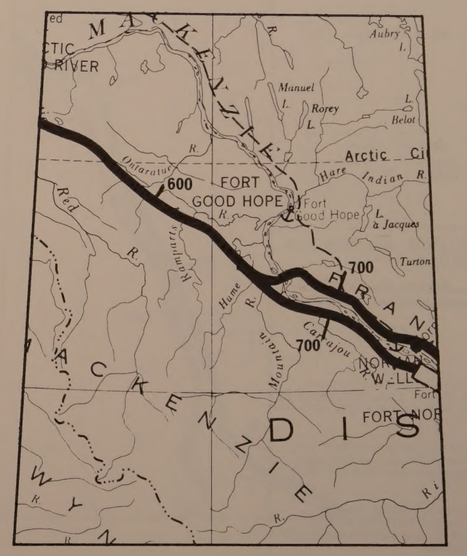


LAT. 64° 60′
LONG. 126° 15′

AVE. ALTITUDE 500′
MEAN ANNUAL AIR TEMP. 22°F

SITE NO. between SHEET NO. 45
37438 PLATE NO. 94

NO PICTURES TAKEN



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Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE		
	TITLE: Photo Mosaic and Terrain Investigation MILE 754 TO MILE 769		
	SUBMITTED: L Jewell	DATE: Dec 70	SITE No.: between 37 & 38
	APPROVED: Cw Spoor	DATE: Dec 70	SHEET No.: 45
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED			PLATE No.: 95

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
				Sand dune.
				Grass-infill.
				Grass island.
				A_0 Picture 1 shows a general view of the Little Bear River and surroundings. Picture 2 shows 120' high active thaw bank merging into a slide at the downstream end. Pictures 3, 4 and 5 are of the material in the thaw bank which was mainly granular and reasonably well graded from cobbles to silt.
				Esker-like ridge.
				Steep bank 70' high.
				B_0 Picture 1 shows Little Bear River with undercut slide in foreground.
				Grass-infilling lakes.
				Grass-infilling lakes.
				Deeply eroded valley.

SEGREGATED ICE NOT VISIBLE BY EYE

4"

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

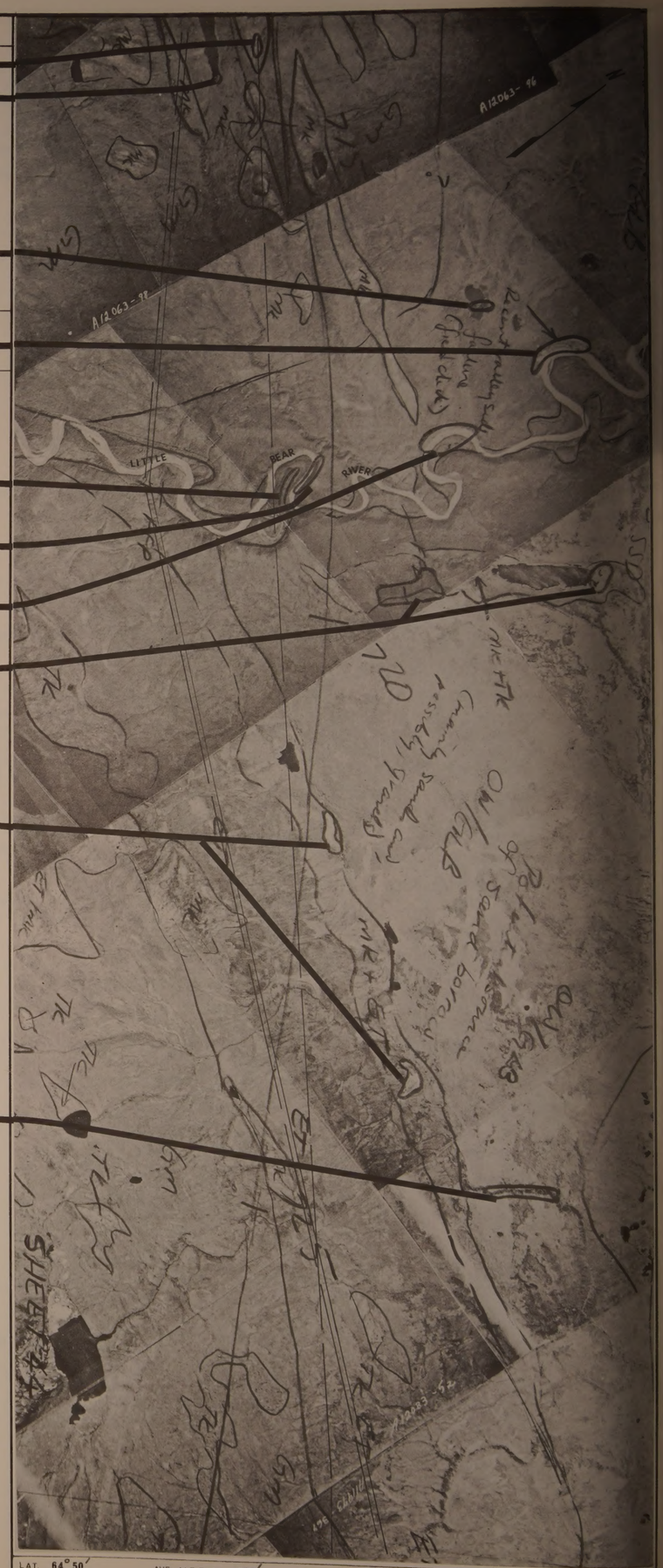
LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on ice-rich organic and inorganic waterlaid silt and fine sand
ET	Gently to moderately sloping water-eroded (sheet erosion) till or bedrock plain; mainly thin ice-rich or sand mantle over till or bedrock
OW	Glacial outwash; mainly sand and gravel with minor silt, often with thin silt mantle
GLB	Thick glacial-lake materials; mainly ice-rich silt and fine sand with minor clay
OSF	Old slide features; mainly weak stratified (sand over silt and clay) glacial-lake deposits or bentonitic clay shales

SEE PLATE No. 3 for a comprehensive description of symbols.

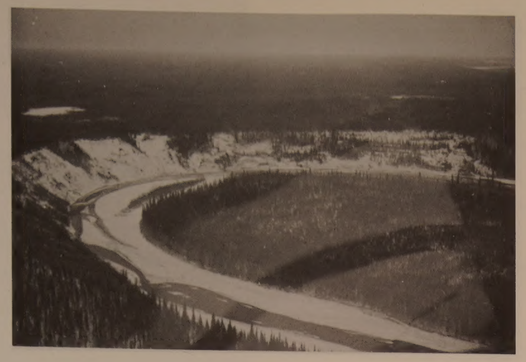


LAT. 64° 50′ LONG. 125° 55′ AVE. ALTITUDE 500′ MEAN ANNUAL AIR TEMP. 23°F

SITE NO between 37 38 SHEET NO. 44 PLATE NO. 96

Picture: 1 Little Bear River.

Site: B_0



Picture: 2 View of loop showing active thaw bank.

Site: A_0

Picture: 3 Toe of thaw bank.

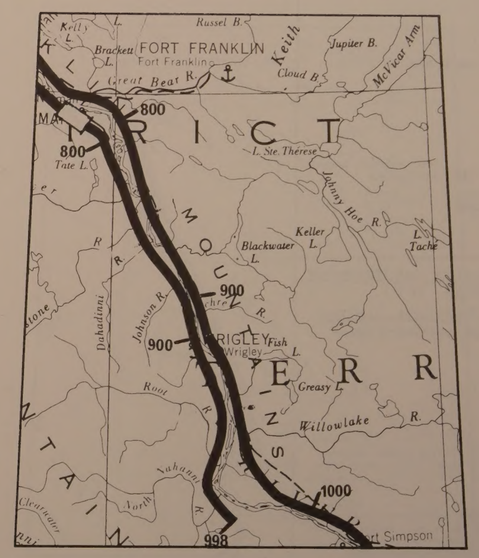
Site: A_0

Picture: 4 Close-up of gravel outcrop 40' from base of thaw bank.

Site: A_0

Picture: 5 View of top of thaw bank.

Site: A_0



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Pictures taken in late October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE
	TITLE: Photo Mosaic and Terrain Investigation MILE 768 TO MILE 783
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: R Jewell; DATE: Dec/70; SITE No.: between 37 & 38; PLATE No.: 97; APPROVED: Ewd Speer; DATE: Dec/70; SHEET No.: 44

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

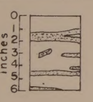
Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ICE-

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and sub-rounded in foothill regions
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand
MK	Muskeg, swamp, marsh, bog; includes all unpatterned peatlands
ET	Gently to moderately sloping water-eroded (sheet erosion) till or bedrock plain; mainly thin ice-rich silt or sand mantle over till or bedrock
GLB	Thick glacial-lake materials; mainly ice-rich silt and fine sand with minor clay

SEE PLATE No 3 for a comprehensive description of symbols.

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	>25' "

Grass-infilled area.

Lake is grass-infilling from north west.

Picture 1 shows Little Birch River.

Lakes well-defined on north end slight grass-infill from south.

Picture 2 shows general area.

Light tamarack and spruce to 30' in height on ridges up to 5' above surrounding ground level.

Single row of light spruce surrounds lake.

Area is generally lightly timbered spruce with dense narrow stands of spruce to 30' in height in the depressional linear areas.

Grass-infilling TK area.

Narrow well-defined creek with heavy spruce to 40' on banks.

All lakes are grass-infilling.

Tamarack and birch to 30'; darker zones indicate area of spruce 10' & 15' high.

LAT. 64°30'
LONG 125°10'

AVE. ALTITUDE 800'
MEAN ANNUAL AIR TEMP. 22°F

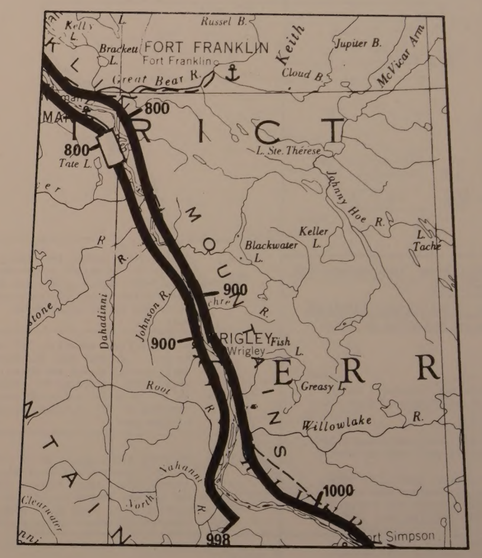
SITE NO between 36 & 38 SHEET NO. 42 PLATE NO. 98

Picture: 1 Little Birch River looking west. View from 4000'.

Site: A_0

Picture: 2 General area from 4000'

Site: B_0



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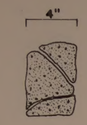
Pictures taken in late October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER. EDMONTON CALGARY REGINA. WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE TITLE: Photo Mosaic and Terrain Investigation MILE 798 TO MILE 811
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: R Jewell DATE: Dec/70 SITE No.: between 37 & 38 PLATE No.: 99 APPROVED: DATE: Dec/70 SHEET No.: 42

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL — ABBREVIATED DESCRIPTION OF TERRAIN

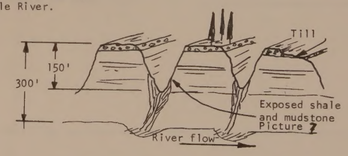
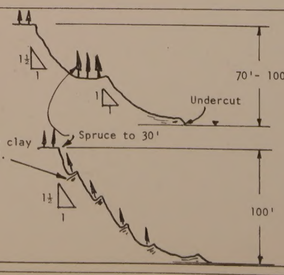
GLB - Thick glacial-lake materials; mainly ice-rich silt and fine sand with minor clay

FFP - "Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel

TK - Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand

ET - Gently to moderately sloping water-eroded (sheet erosion) till or bedrock plain; mainly thin ice-rich silt or sand mantle over till or bedrock

SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
			Grass-infilling with treed islands.
			Grass islands.
			Esker-like ridge.
			Extensive ridge.
			Lake is grass-infilling on northern edge.
			Infilled drainage channel.
			Grass-infilled lake in muskeg area.
38 F_T	Tamarack and willows to 3' on test site. Adjacent to test site; dense black spruce to 60', tamarack to 40', and willows to 8'; labrador tea, bearberry and moss.	0 - ½' PEAT ½' - 3' CLAY and SILT, frozen at 1' ice lenses (Vs) 3' - 21' SAND, fine, silt lenses, no visible ice, (Nbn)	38 F_T Test hole in natural clearing in heavily timbered terrace. Picture 1 shows trees adjacent to the site which was 300' from a 150' high ridge.
38 E_T	Bog willows, swamp laurel, grass, moss; heavy growth of black spruce to 15' (few to 35'), white spruce to 10' and small tamarack adjacent to the test site.	0 - 8' PEAT 8' - 20' SAND and GRAVEL, well graded, unfrozen	38 E_T Test hole adjacent to infilling lake shown in Picture 2 on FFP. Picture 3 shows surface and vegetation near test hole.
38 D_T	Grass, moss and swamp laurel. Heavy growth of black spruce and some tamarack to 30', bog willow and dwarf birch.	0 - 4' PEAT, unfrozen 4' - 5½' SILT, sandy, unfrozen 5½' - 20' SAND, gravelly, unfrozen	38 D_T Test hole in muskeg swamp and located as shown in Picture 4 and Picture 5 shows vegetation adjacent to swamp.
			38 C_0 Flood plain; gravel and cobbles to 6" identified as quartzite, sandstone, siltstone, slate and granite.
			38 B_0 Banks to 300' in height are exposed grey shale and mudstone as in Picture 6 and 7, capped by till to 10' in thickness. Flood plain is topped by 2' of plastic clay from shale erosion. Active erosion has cut deep valleys perpendicular to Keele River. 
38 A_T	Sparse black spruce and tamarack to 10' in height. Labrador tea, swamp laurel, grass and moss. Dense black spruce and tamarack to 20' in height adjacent to site.	0 - 4' PEAT unfrozen 4' - 5½' SAND, medium, unfrozen 5½' - 15' SILT, unfrozen 15' - 20½' CLAY, silty, unfrozen, soft	38 A_T Test hole in muskeg swamp near an infilled lake. Picture 8 shows vegetation at test site.
38 H_T	Moderate black spruce to 15' in height. Labrador tea, bearberry, fern, grass, lichen and moss. Heavy black spruce to 45', birch to 30' in height and occasional tamarack to 50' in height at edge of thaw pond.	0 - 2' PEAT 2' - 5' SAND, grey, frozen, no visible ice, (Nbn) 5' - 21' SILT, clayey, 15% ice, in lenses and crystals (Vr, Vx)	38 H_T Test hole located in TK area as shown in Picture 9. Picture 10 is a general view near the site. Picture 11 shows ice inclusions in a sample.
38 G_T	Moderate black spruce to 10' in height; tamarack and dwarf birch; lichen, moss, swamp laurel, labrador tea and bearberry. In the surrounding area, light dwarf pine, tamarack and black spruce to 20'.	0 - 2½' PEAT, frozen at 21", ice lenses and crystals (Vx, Vr) 2½' - 5½' SAND, fine, no visible ice (Nbn) 5½' - 10½' SILT, 15% ice, in lenses (Vs) 10½' - 20½' SAND, fine to medium, no visible ice, (Nbn)	38 G_T Test hole in a partial clearing in TK area. Picture 12, general view near the site.
			Grass-infilled area with very little tree growth. Surrounding area is heavy spruce.
			38 I_0 Extensive slide on west bank of Mackenzie River appears to have developed by undercutting. Some sections appear to have moved in one or two blocks while others have numerous benches. Heavy spruce to 30' line the top of bank. Material appears to be generally clay and shale overlain by silty sand. 
			Grass-infilled water course.

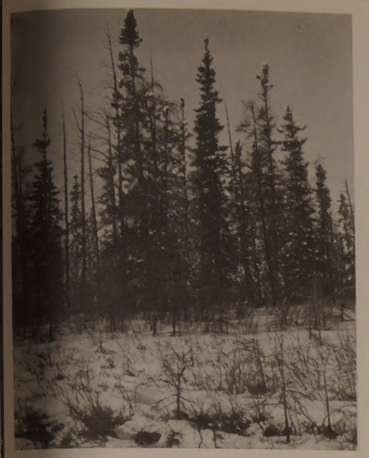
NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

LAT. 64° 20'
LONG. 124° 50'

AVE. ALTITUDE 450'
MEAN ANNUAL AIR TEMP. 22° F

SITE NO. 38 SHEET NO. 41
PLATE NO. 100



Picture: 1
View across test hole site.

Site: 38 F_T

Picture: 2 General view of site.

Site: 38 E_T

Picture: 3 View looking north near test hole site.

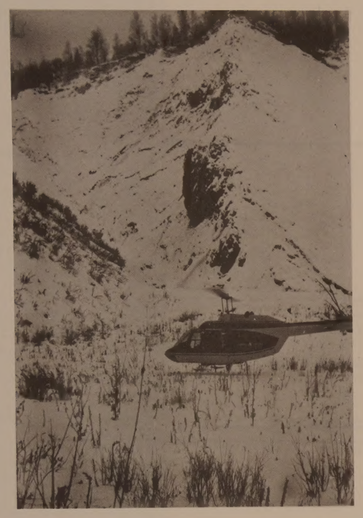
Site: 38 E_T

Picture: 4 Location of test hole.

Site: 38 D_T

Picture: 5 View looking west across test hole site.

Site: 38 D_T



Picture: 6 Shale and mudstone bank on Keele River with erosion channels 100' deep, perpendicular to river.

Site: 38 B_0

Picture: 7 Close-up of bank shown in Picture 6.

Site: 38 B_0

Picture: 8 View across test hole site.

Site: 38 A_T

Picture: 9 Site location in thermokarst area.

Site: 38 H_T

Picture: 10 View across test hole site.

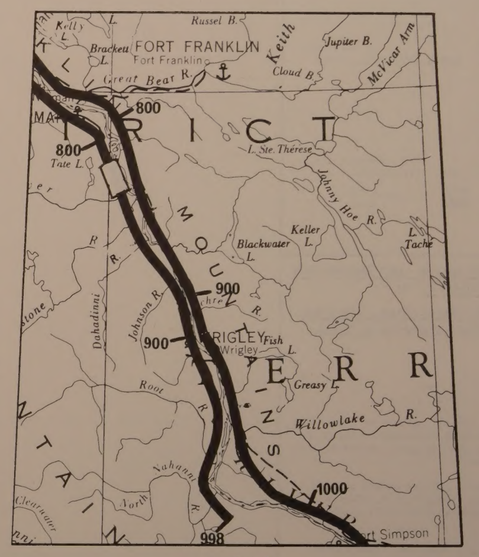
Site: 38 H_T

Picture: 11 Test hole sample recovered from the 10' to 12' interval.

Site: 38 H_T

Picture: 12 View at edge of test hole site.

Site: 38 G_T



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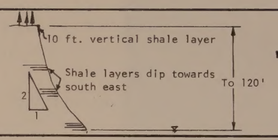
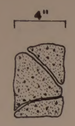
Pictures taken in late October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE			
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	TITLE: Photo Mosaic and Terrain Investigation MILE 811 TO MILE 826			
	SUBMITTED: L Jewell	DATE: Dec/70	SITE No.: 38	PLATE No.: 101
	APPROVED: [signature]	DATE: Dec/70	SHEET No.: 41	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
				Treed islands -- spruce to 30'.
				Entire area is heavily timbered, spruce to 30'.
				Grass and tree infill on all banks.
				Extensive sand and gravel deposits on AFP in river.
				A_0 Shale banks to 120' in height as shown in Picture 1. Slope of bank is as sketched. Shale strata dip toward south east. Moderate to heavy spruce on top of bank. 
				Steep shale and limestone banks rising from river.
				Extensive gravel deposits in river.
				TK area with heavy spruce, birch, poplar and tamarack to 30'.
				Extensive TK area with heavy spruce and tamarack to 30'.

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ICE-

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel
AFP	Active flood plain; mainly exposed sand, gravel and cobbles with boulders locally
GLB	Thick glacial-lake materials; mainly ice-rich silt and fine sand with minor clay
→	Drumlinized and/or fluted surface; mainly isolated patches of silt over thin till over bedrock or over fluted bedrock
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions

SEE PLATE No 3 for a comprehensive description of symbols.

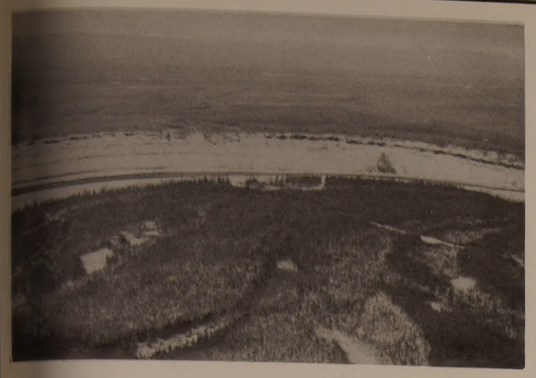
NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

LAT. 64° 10'
LONG 124° 40'

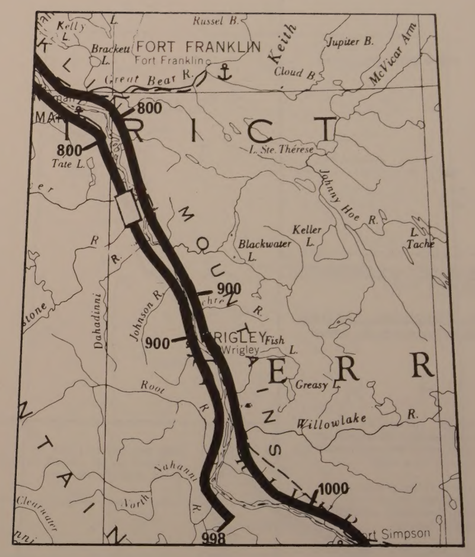
AVE. ALTITUDE 500'
MEAN ANNUAL AIR TEMP. 22°F

SITE NO. between SHEET NO. 40
38 & 39 PLATE NO. 102



Picture: 1 Right bank of Redstone River.

Site: A_0



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Picture taken in late October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE TITLE: Photo Mosaic and Terrain Investigation MILE 827 TO MILE 842
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: L Jewell — DATE: Dec/70 — SITE No.: between 38 & 39 — PLATE No.: 103 APPROVED: — DATE: Dec/70 — SHEET No.: 40

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

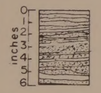
Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

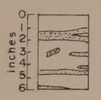
Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS



Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ▒ ICE- □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL — ABBREVIATED DESCRIPTION OF TERRAIN

TK - Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand.

GM - Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally

FFP - "Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel

BR - Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions

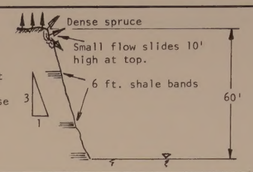
ET - Gently to moderately sloping water-eroded (sheet erosion) till or bedrock plain; mainly thin ice-rich silt or sand mantle over till or bedrock

SEE PLATE No 3 for a comprehensive description of symbols.

Light spruce to 15' in TK area.

Treed island.

39 E_0 — 60' high river bank exposing strata of shale to 6' thick and sand or sandstone to 1½'. Bank profile is as sketched and drainage channels at right angles to the river divide the bank at regular intervals. Dense spruce to 30' high line the top of the bank.



Thermokarst area grass-infilled.

Lake is grass and tree infilling all round.

Note scale change and displacement of mosaic.

Undercut bank 120' high. Shale and sand under 6' till cover.

39 B_0 — Dahadinni River bank eroding at the toe and sliding as shown in Picture 1. Samples recovered indicate that the bank material varies from till-like gravelly clay at the base up to sand and gravel and cobble strata in the top 30'. The river bank is up to 150' high with heavy spruce and birch to 20' high on the slope.
Extensive sand and gravel deposits in the river.

100' high bank with slumping in lower 60'.

39 A_T — Moderate black spruce to 10', tamarack to 20'; dwarf birch, grass and labrador tea.

0 - 8" PEAT
8" - 8' SILT, sandy, unfrozen
8' - 17' CLAY, silty, till-like, frozen at 8', ice 5% in lenses (Vr)

39 A_T — Test hole located as shown in Picture 2. Pictures 3 and 4 show general details including dead trees which indicate an old burn.

Treed island.

39 C_T — Light black and white spruce to 25', tamarack to 35', and clumps of dense birch to 25'; willow thickets to 15', labrador tea, cassandra, leatherleaf, bog bilberry, lichen and moss.

0 - 3½' PEAT, frozen at 2', ice lenses and crystals (Vx,Vr)
3½' - 21' SILT, ice lenses and crystals, (Vx,Vr)

39 C_T — Test hole located between two lakes as shown in Picture 5. Picture 6 shows dense birch adjacent to the site and Picture 7 shows ice lenses in sample recovered from test hole.

39 D_T — Moderate birch and black spruce to 40'; willow clumps and dwarf birch; labrador tea, lichen, moss, bog bilberry and leatherleaf.

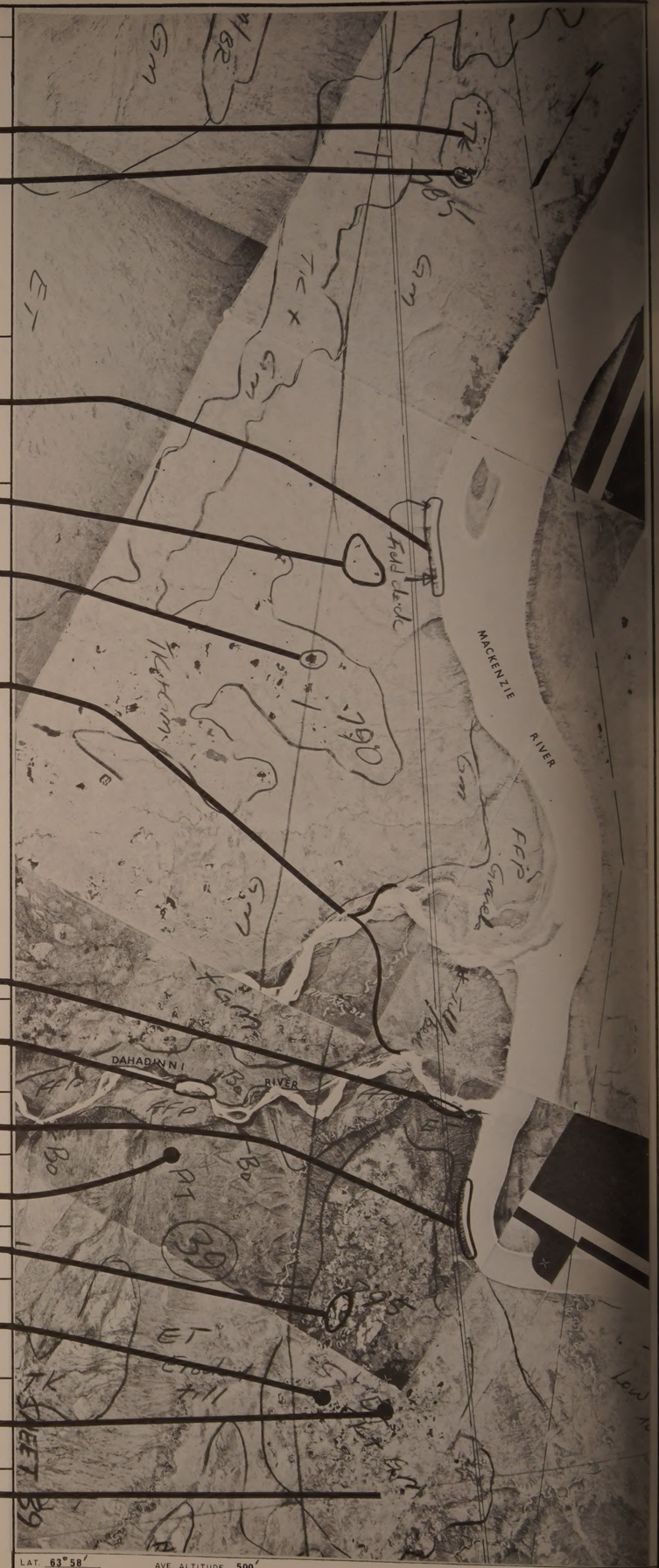
0 - 3' PEAT, frozen at 2', ice crystals, (Vx)
3' -21½' SILT, clayey, 60% ice, in lenses, till-like below 20½' (Vs)

39 D_T — Test hole located on high ground between lakes in TK terrain as shown in Picture 8. Picture 9 shows a general view from the test site to the lake level 20' lower, and Picture 10 shows ice lenses in sample recovered from test hole.

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	>25' "

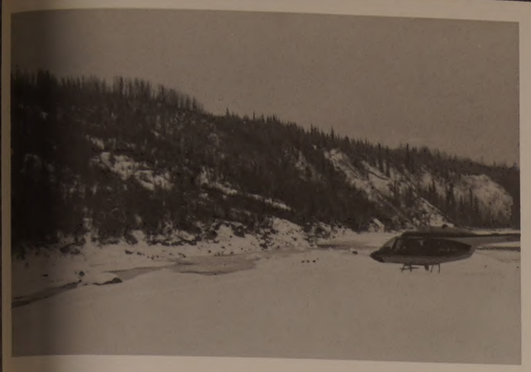
Medium to heavy spruce to 30' generally covers entire TK and GM area.



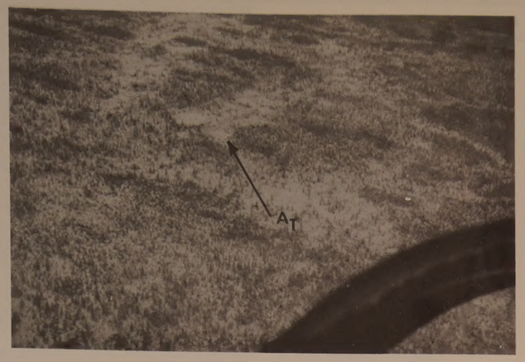
LAT. 63°58'
LONG 124°25'

AVE. ALTITUDE 500'
MEAN ANNUAL AIR TEMP. 22°F

SITE NO 39 SHEET NO. 39
PLATE NO. 104



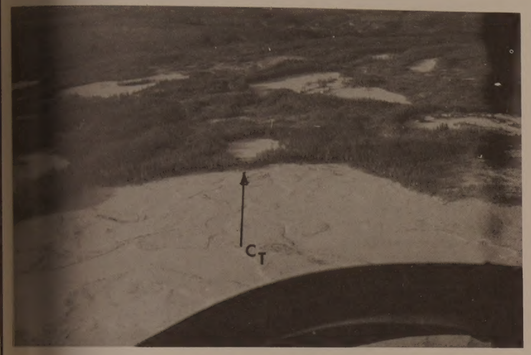
Picture: 1 Looking east along Dahadinni River bank.
Site: 39 B_0



Picture: 2 Test hole location
Site: 39 A_T

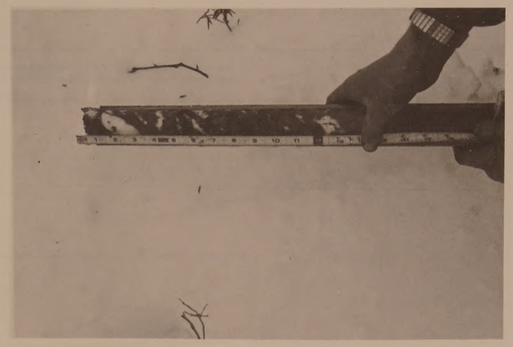
Picture: 3 View across test hole site.
Site: 39 A_T

Picture: 4 Close-up of trees alongside site.
Site: 39 A_T

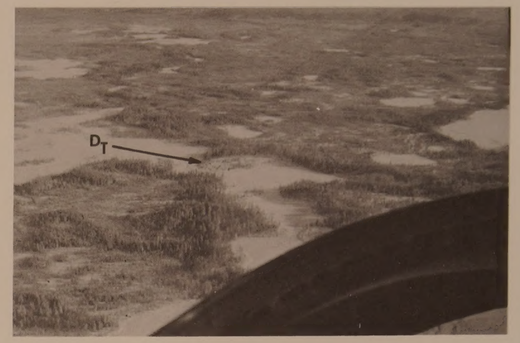


Picture: 5 Looking west at test hole location.
Site: 39 C_T

Picture: 6 Birch at test hole site.
Site: 39 C_T

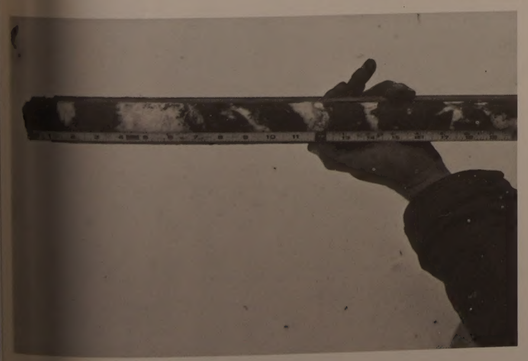


Picture: 7 Sample 3 at 5' depth.
Site: 39 C_T

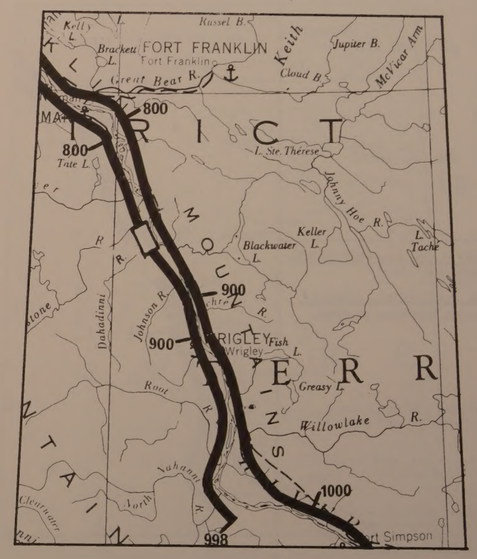


Picture: 8 Looking east at test hole site.
Site: 39 D_T

Picture: 9 Looking north from test hole site.
Site: 39 D_T



Picture: 10 Sample 4 at 10' depth.
Site: 39 D_T



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Pictures taken in late October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG CLIENT MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	PROJECT MACKENZIE VALLEY PIPELINE TITLE Photo Mosaic and Terrain Investigation MILE 841 TO MILE 856 SUBMITTED R Jewell — DATE Dec/70 — SITE No. 39 — PLATE No. 105 APPROVED Curl Speer — DATE Dec/70 — SHEET No. 39

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

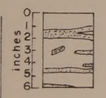
Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ICE-

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
GLB	Thick glacial-lake materials; mainly ice-rich silt and fine sand with minor clay
OW	Glacial outwash; mainly sand and gravel with minor silt, often with thin silt mantle
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions
ET	Gently to moderately sloping water-eroded (sheet erosion) till or bedrock plain; mainly thin ice-rich silt or sand over till or bedrock
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand
GM	Level to gently rolling ground moraine; m mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
→	Drumlinized and/or fluted surface; mainly isolated patches of silt over thin till over bedrock or over fluted bedrock

SEE PLATE No 3 for a comprehensive description of symbols.

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

Heavy spruce to 25' line banks of creeks.

Heavy spruce growth in TK and GM areas.

Different shading on mosaic appear to coincide with clumps of birch amongst the heavy black spruce predominant in the area.

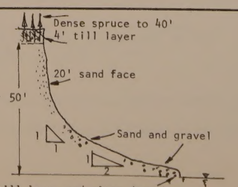
Distinct ridge 120' high.

Heavy spruce over entire ET area.

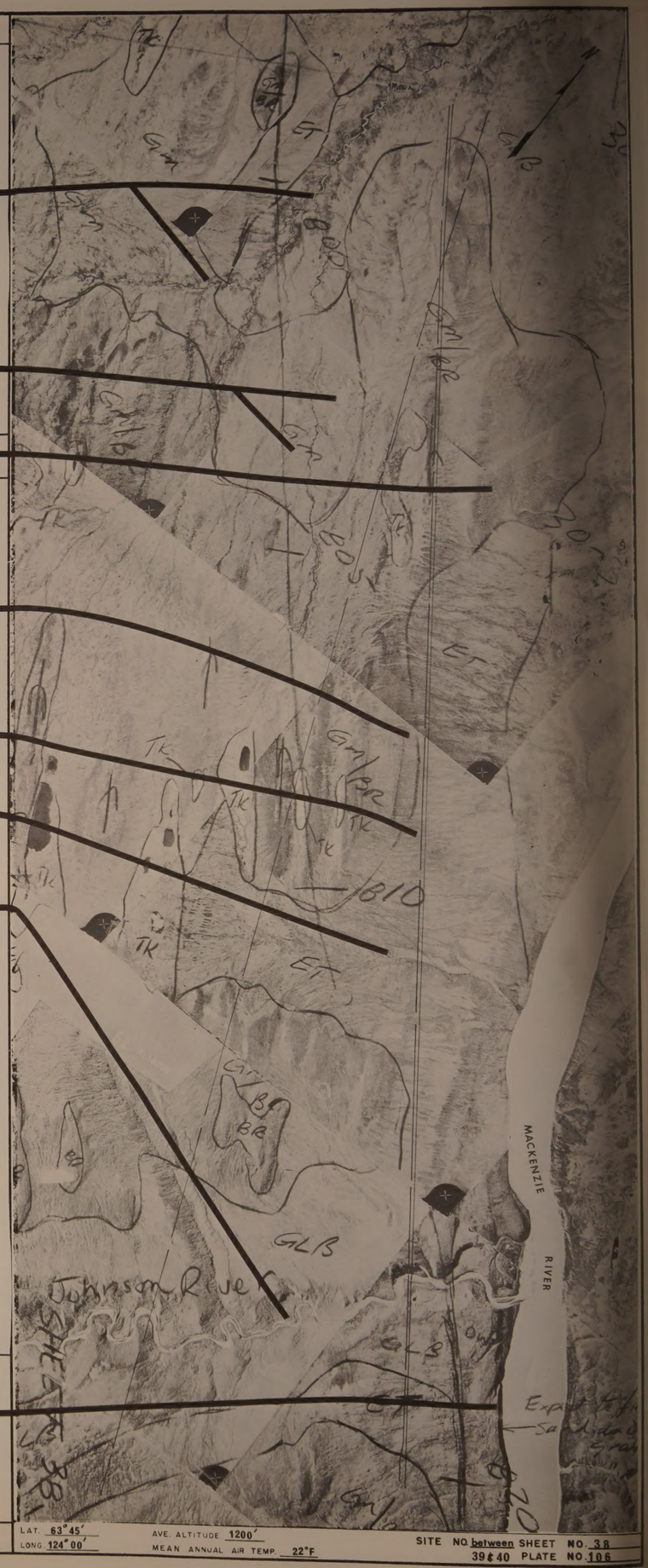
Tamarack and birch line creek.

Heavy spruce to 40' line Johnson River and flood plains.

A_0 Observation of river bank showed 50' of sand overlain by 4' to 6' of till-like material as sketched. Picture 1 shows bank and vertical sand face 20' high and Picture 2 shows overlying till-like material. The sand is fine with approx. 30% silt size particles.



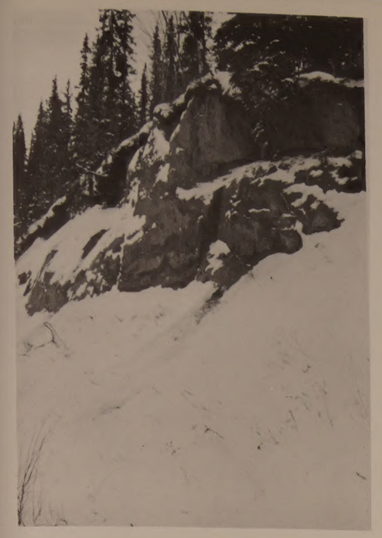
Gravel from till layer and river deposits.



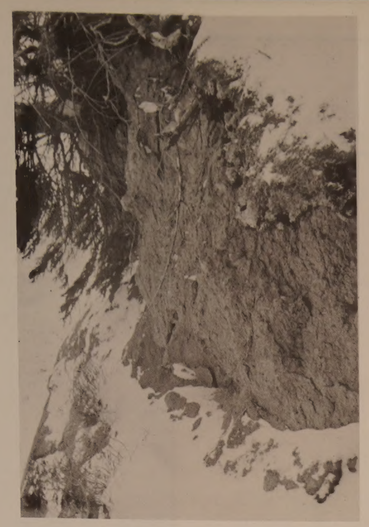
LAT. 63°45'
LONG. 124°00'

AVE. ALTITUDE 1200'
MEAN ANNUAL AIR TEMP. 22°F

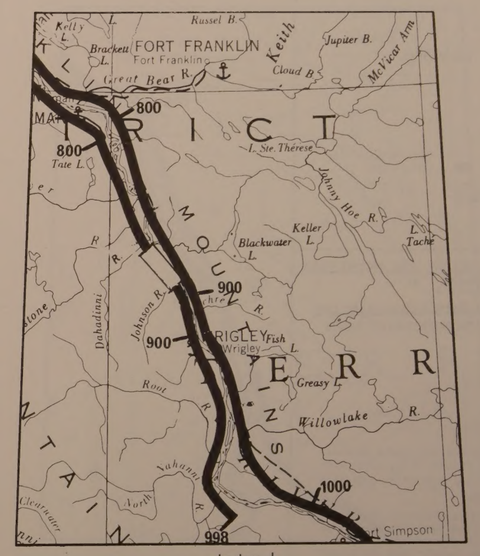
SITE NO. between SHEET NO. 38 39 & 40 PLATE NO. 106



Picture: 1 25' high sand exposure on west bank of Mackenzie River.
Site: A_0



Picture: 2 4' thick till layer overlying sand in the river bank.
Site: A_0



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Pictures taken in late October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE		
	TITLE: Photo Mosaic and Terrain Investigation MILE 855 TO MILE 876		
	SUBMITTED: R Jewell	DATE: Dec 15/70	SITE No.: between 39&40 / PLATE No.: 107
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	APPROVED: Ew Speer	DATE: Dec/70	SHEET No.: 38

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
GLB	Thick glacial-lake materials; mainly ice-rich silt and fine sand with minor clay
OW	Glacial outwash; mainly sand and gravel with minor silt, often with thin silt mantle
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions
→	Drumlinized and/or fluted surface; mainly isolated patches of silt over thin till over bedrock or over fluted bedrock

SEE PLATE No 3 for a comprehensive description of symbols.

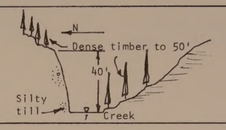
NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

Minor slides on 60' high banks sloping at 3:1 to river.

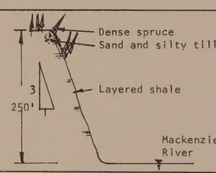
Dense spruce to 40' high cover area.

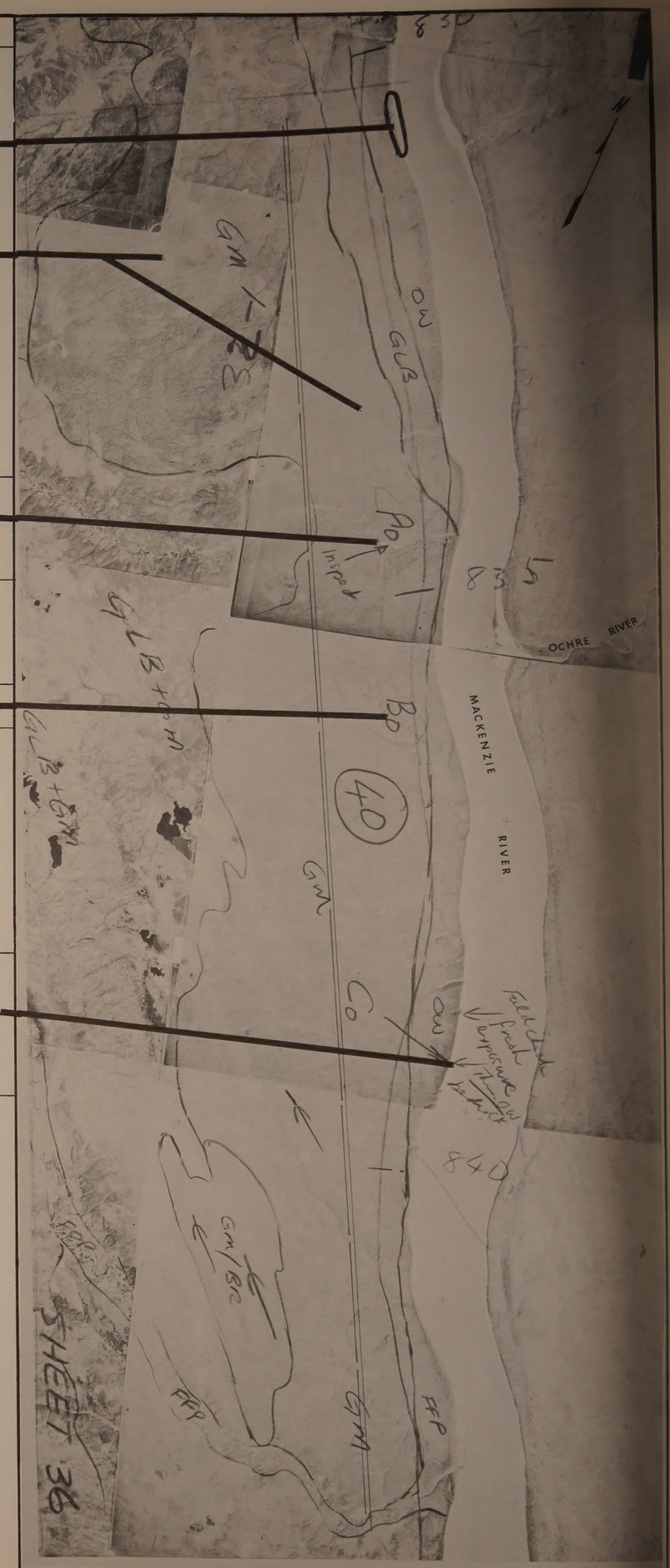
40 A_0 Silty till-like material visible in exposures in 50' high left bank. Heavy spruce to 50' in height and some pine in this area.



40 B_0 Layers of sand and clay-till visible in 50' high bank. Heavy spruce to 50' in height and some pine.

40 C_0 The exposed bank in Picture 1 has a profile of 3' of sand and silty-till over weathered shale as sketched. Dense spruce 40' high on terrace at top of bank.

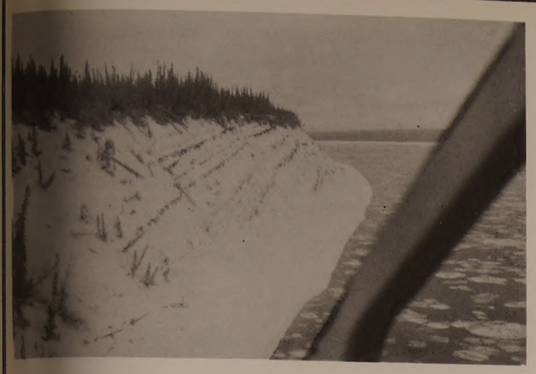




LAT. 63° 25'
LONG. 123° 45'

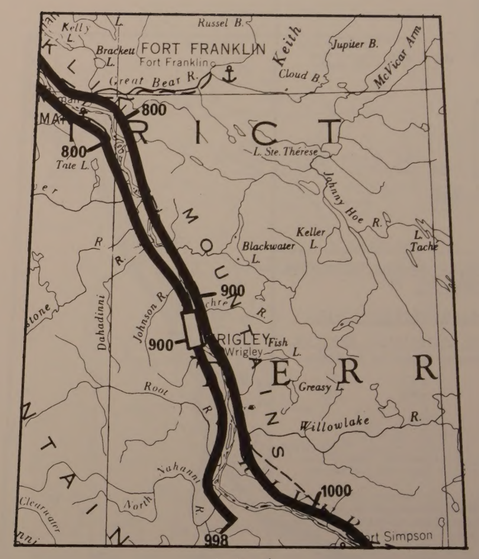
AVE. ALTITUDE 400'
MEAN ANNUAL AIR TEMP. 23°F

SITE NO. 40 SHEET NO. 36
PLATE NO. 108



Picture: 1 250' high shale bank on the Mackenzie River.

Site: 40 C_0



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Pictures taken in late October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE TITLE: Photo Mosaic and Terrain Investigation MILE 887 TO MILE 902
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: L Jewell — DATE: Dec/70 — SITE No. 40 — PLATE No. 109 APPROVED: Ev Speer — DATE: Dec/70 — SHEET No. 36

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard & Associates Ltd.

J. D. Mollard and Associates Limited

MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic water-laid silt and fine sand
MK	Muskeg, swamp, marsh, bog; includes all unpatterned peatlands
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions
OW	Glacial outwash; mainly sand and gravel with minor silt, often with thin silt mantle
GLB	Thick glacial-lake materials; mainly ice-rich silt and fine sand with minor clay

SEE PLATE No 3 for a comprehensive description of symbols.

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

Deeply eroded drainage channel with 70' high banks.

Lake is grass-infilling.

Grass-infill between lakes.

Poplar and birch in OW and GM area.

Grass-infilling areas.

Treed ridge extending into the lake.

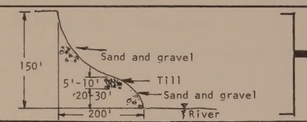
OW area has poplar, tamarack and spruce to 20'.

Well-defined lake.

Original location of Wrigley settlement -- now deserted.

OW ridges -- sand and gravel on surface.

Slide in sand and gravel overlying silty-till. (See sketch).
Below the till layer are further strata of sand and gravel.



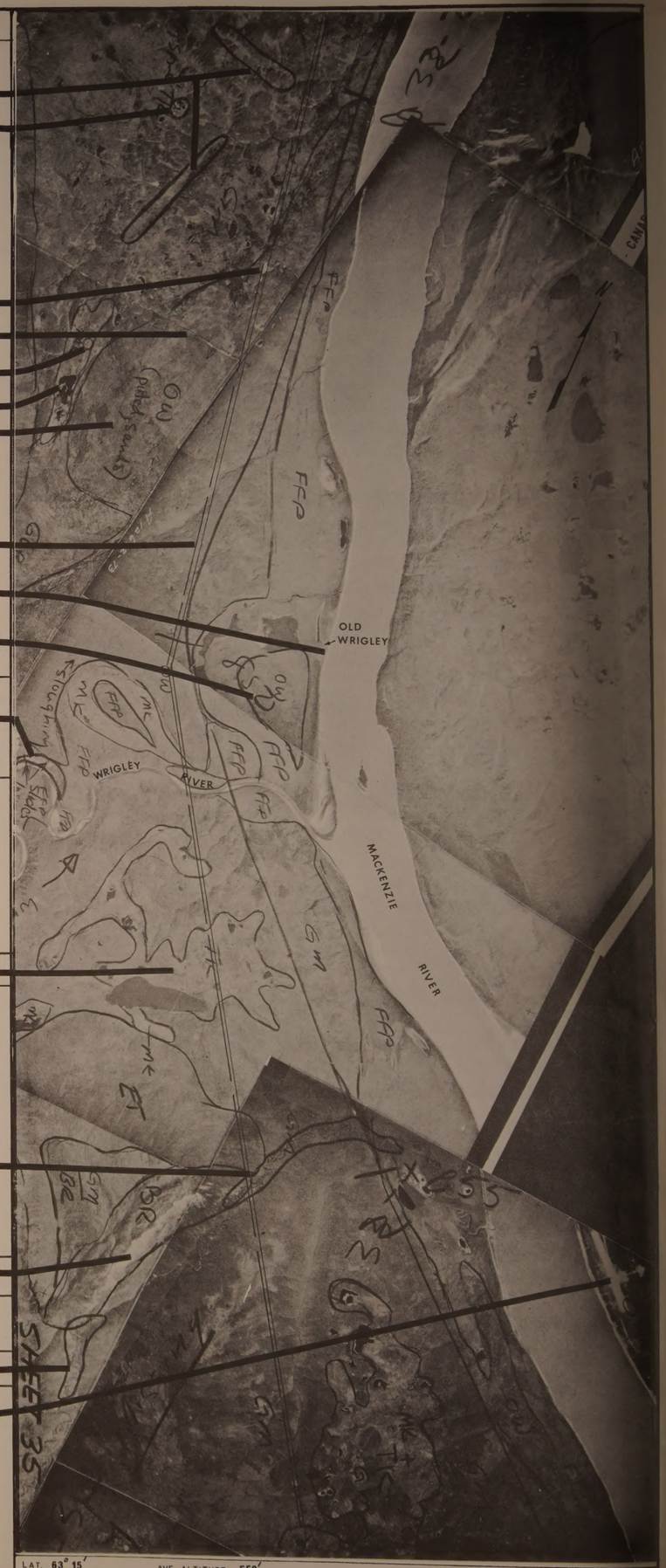
Lakes in TK area have well-defined 2' to 3' high banks covered with light spruce to 15'.

Meandering creek has dense spruce growth to 25' in height on banks.

Exposed ridges of shale and limestone strata which dip at 45° to the west.

Heavy spruce to 40' in height, line 150' to 200' high banks of deeply eroded channel.

Wrigley airfield.

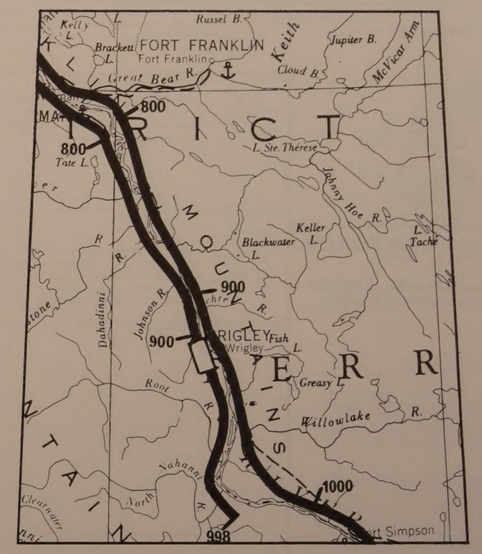


LAT. 63° 15'
LONG 123° 35'

AVE. ALTITUDE 550'
MEAN ANNUAL AIR TEMP. 23°F

SITE NO between SHEET NO. 35
40 & 41 PLATE NO. 110

NO PICTURES TAKEN



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Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: **MACKENZIE VALLEY PIPELINE**				
	TITLE: Photo Mosaic and Terrain Investigation MILE 902 TO MILE 917				
	SUBMITTED: R Jewell	DATE: Dec/70	SITE No.: 40 & 41	PLATE No.: 111	
CLIENT: **MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED**	APPROVED: Ewlpeer	DATE: Dec/70	SHEET No.: 35		

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE.

Nf POORLY BONDED

Ndn WELL BONDED – NO EXCESS ICE

Nbe WELL BONDED – EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK.

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ICE-

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

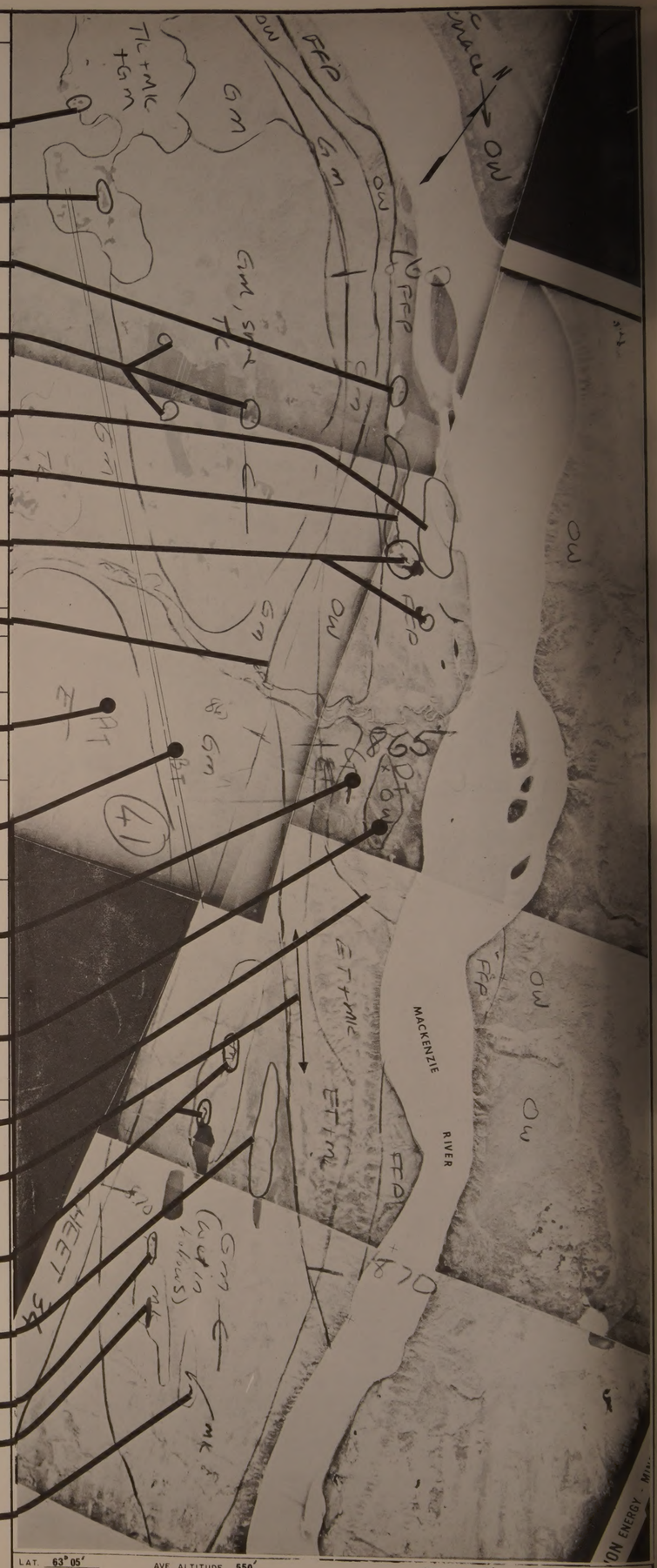
MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
MK	Muskeg, swamp, marsh, bog; includes all unpatterned peatlands
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel
OW	Glacial outwash; mainly sand and gravel with minor silt, often with thin silt mantle
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand
ET	Gently to moderately sloping water-eroded (sheet erosion) till or bedrock plain; mainly thin ice-rich silt or sand mantle over till or bedrock
→	Drumlinized and/or fluted surface; mainly isolated patches of silt over thin till over bedrock or over fluted bedrock

SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
			Only one lake observed here in the field.
			Grass and tree infilling on all banks.
			Grass infilled.
			Lake is well-defined with grass and tree infill in some areas.
			Spruce and tamarack to 30' high in most areas.
			Drainage path has infilled with grass.
			Extensive grass infilling.
			Areas of tamarack and birch line top of bank; black spruce line the creek.
41 A_T	Sparse black spruce and tamarack to 30' in height; bearberry, swamp laurel, leather leaf, moss and lichen.	0 - ½' ORGANIC ½' - 10' SILT, organic, frozen below 3½', ice crystals (Vx) 10' - 22' SILT, clayey, (till-like) ice crystals and lenses, (Vr, Vx)	41 A_T Test hole situated as shown in Picture 1, is in an old fire burn as can be seen by the dead trees in Picture 2.
41 B_T	Sparse black spruce, pines and tamarack to 30' in height; leather-leaf, labrador tea, horsetail, moss and grass.	0 - 4" ORGANIC 4" - 5' SILT, clayey 5' - 22' SILT, clayey, sandy, (till-like), unfrozen	41 B_T Test hole situated as shown in Picture 3. Picture 4 shows vegetation on the old fire burn in which the hole was located.
41 C_T	Light black spruce and tamarack to 30' in height. Swamp laurel, leatherleaf, labrador tea, lichen and grass.	0 - 4' PEAT, frozen below 3', ice lenses and crystals (Vx, Vr) 4' - 14' SILT, peat layers, ice crystals and lenses (Vx, Vr) 14' - 15' GRAVEL 15' - 22' SAND, silty, (till-like) ice lenses and crystals (Vr, Vx)	41 C_T Test hole adjacent to small pond as shown in Picture 5. Picture 6 shows an ice lense in a sample recovered from the test hole.
41 D_T	Moderate black spruce to 30' in height in the drainage channel. Bearberry, labrador tea, lichen and moss. Heavy black spruce and pines to 60' in height adjacent to the site.	0 - 2' PEAT 2' - 8' SAND, silty, ice crystals and lenses (Vx, Vr) 8' - 22' SILT, sandy, (till-like), no visible ice, (Nbn)	41 D_T Test hole in shallow drainage channel in outwash plain remnant. Picture 7 shows test hole location, and a closer view of the drill site is shown in Picture 8.
			Poorly defined creek in lightly timbered area.
			Generally ET; only occasional areas of MK
			Lakes are infilling with grass.
			Light spruce to 20' in MK area.
			Grass-infilling drainage channel.
			Lake has well-defined banks with spruce to 20' high.
			Lake is grass-infilling with treed islands.

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "



LAT. 63° 05′ LONG 123° 15′

AVE. ALTITUDE 550′

MEAN ANNUAL AIR TEMP. 24°F

SITE NO. 41 SHEET NO. 34

PLATE NO. 112

Picture: 1 Looking west at test hole location.

Site: 41 A_T

Picture: 2 General view of test site.

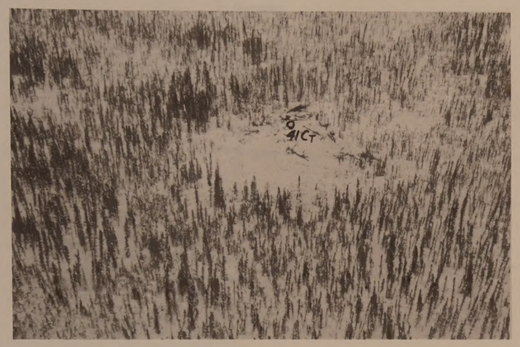
Site: 41 A_T

Picture: 3 Test hole location.

Site: 41 B_T

Picture: 4 Looking NE across test site.

Site: 41 B_T

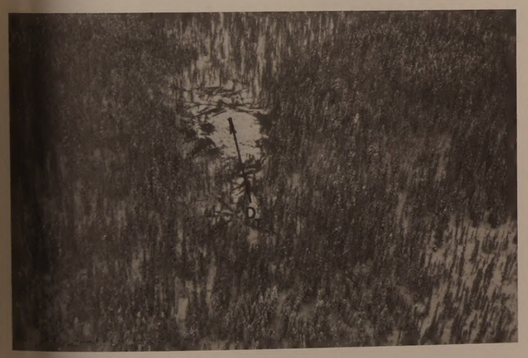


Picture: 5 Test hole location.

Site: 41 C_T

Picture: 6 Sample #4 taken from 10' to 12' depth showing ice lense.

Site: 41 C_T

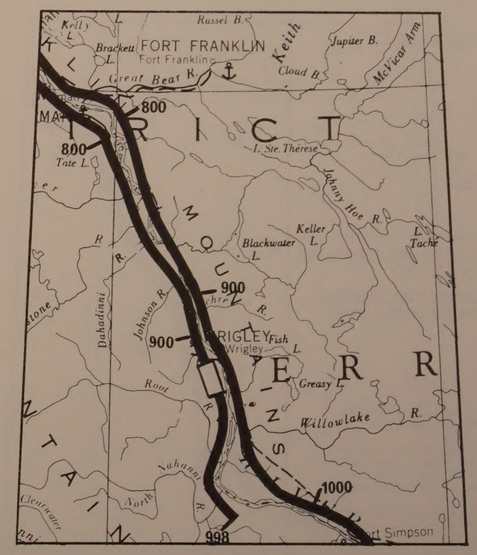


Picture: 7 Test site prior to final clean up.

Site: 41 D_T

Picture: 8 Looking north across site showing heavy tree cover.

Site: 41 D_T



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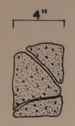
Pictures taken in late October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE
	TITLE: Photo Mosaic and Terrain Investigation MILE 915 TO MILE 930
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: R Jewell DATE: Dec/70 SITE No.: 41 PLATE No.: 113
	APPROVED: DATE: Dec/70 SHEET No.: 34

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

Nbn WELL BONDED – NO EXCESS ICE

Nbe WELL BONDED – EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

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ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL – ICE –

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by–

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GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions
ET	Gently to moderately sloping water-eroded (sheet erosion) till or bedrock plain; mainly thin ice-rich silt or sand mantle over till or bedrock
FFP	"Fossil" (i.e. inactive) flood plain; mainly thin silt over sand and gravel.

SEE PLATE No 3 for a comprehensive description of symbols.

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

Deeply eroded drainage gully.

High ridge covered with black spruce and birch to 30' in height.

Swamp area is willow and grass-infilling.

Mosaic Overlap.

Airstrip.

A_0 Picture 1 shows exposed bank in deeply eroded creek valley.

Light spruce cover to 25' in height.

Ridge covered with heavy spruce to 40' in height surrounded by light spruce to 20' in height.

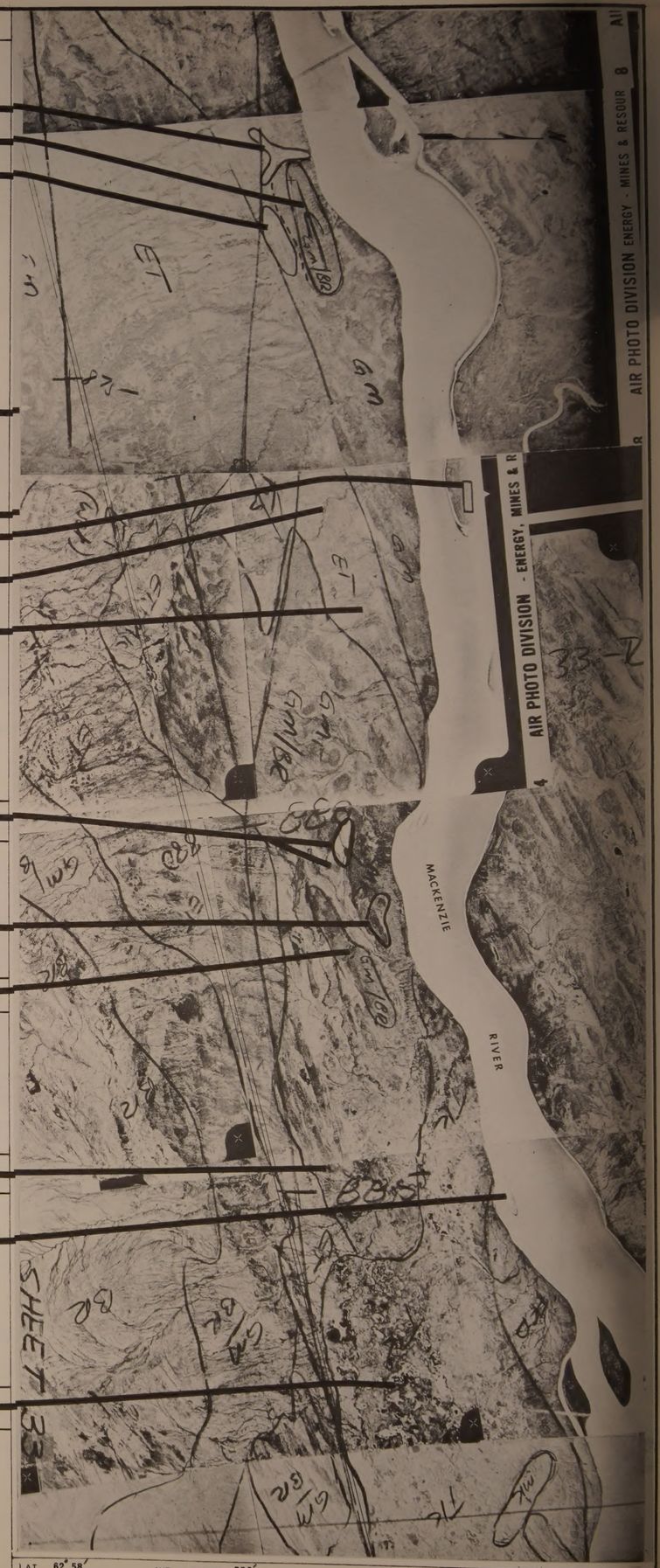
Grass-infilling lakes.

Heavy tamarack, birch and occasional spruce to 30' in height on 60' high ridge.

B_0 Picture 2 taken looking north shows drumlinoidal ridges which are 30' to 40' high and covered with tamarack and birch.

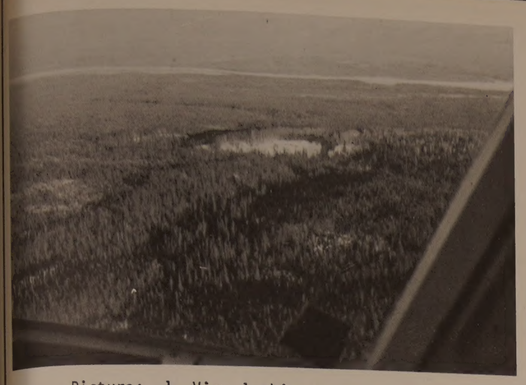
Sand and gravel bar.

C_0 TK area in Picture 3 has grass-infilling in most thaw ponds which are bordered by spruce and tamarack to 20' in height. Palsas 10 to 15' high surround most lakes.



LAT. 62° 58′ LONG. 123° 10′ AVE. ALTITUDE 550′ MEAN ANNUAL AIR TEMP. 24°F

SITE NO between SHEET NO. 33 & 42 PLATE NO. 114



Picture: 1 View looking east toward Mackenzie River and the mouth of the River Between Two Mountains

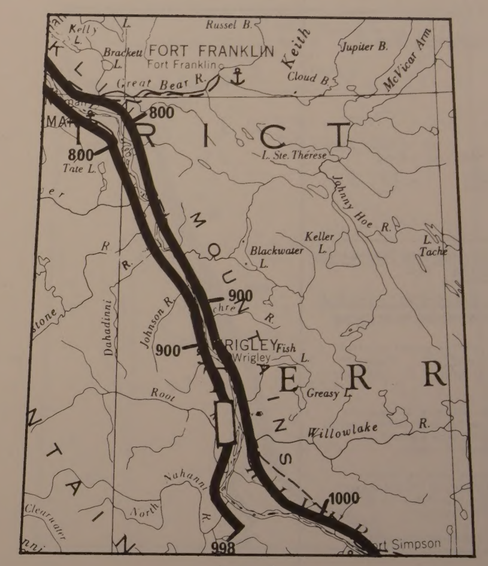
Site: A_0

Picture: 2 Drumlinoidal ridges near the Mackenzie River.

Site: B_0

Picture: 3 View of TK and palsa terrain.

Site: C_0



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Pictures taken in late October, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 929 TO MILE 947

SUBMITTED	DATE	SITE No.	PLATE No.
R Jewell	Dec/70	between 41 & 42	115
APPROVED	DATE	SHEET No.	
Gudgeer	Dec/70	33	

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ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ▒ ICE- □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

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GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally
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TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand
OW	Glacial outwash; mainly sand and gravel with minor silt, often with thin silt mantle

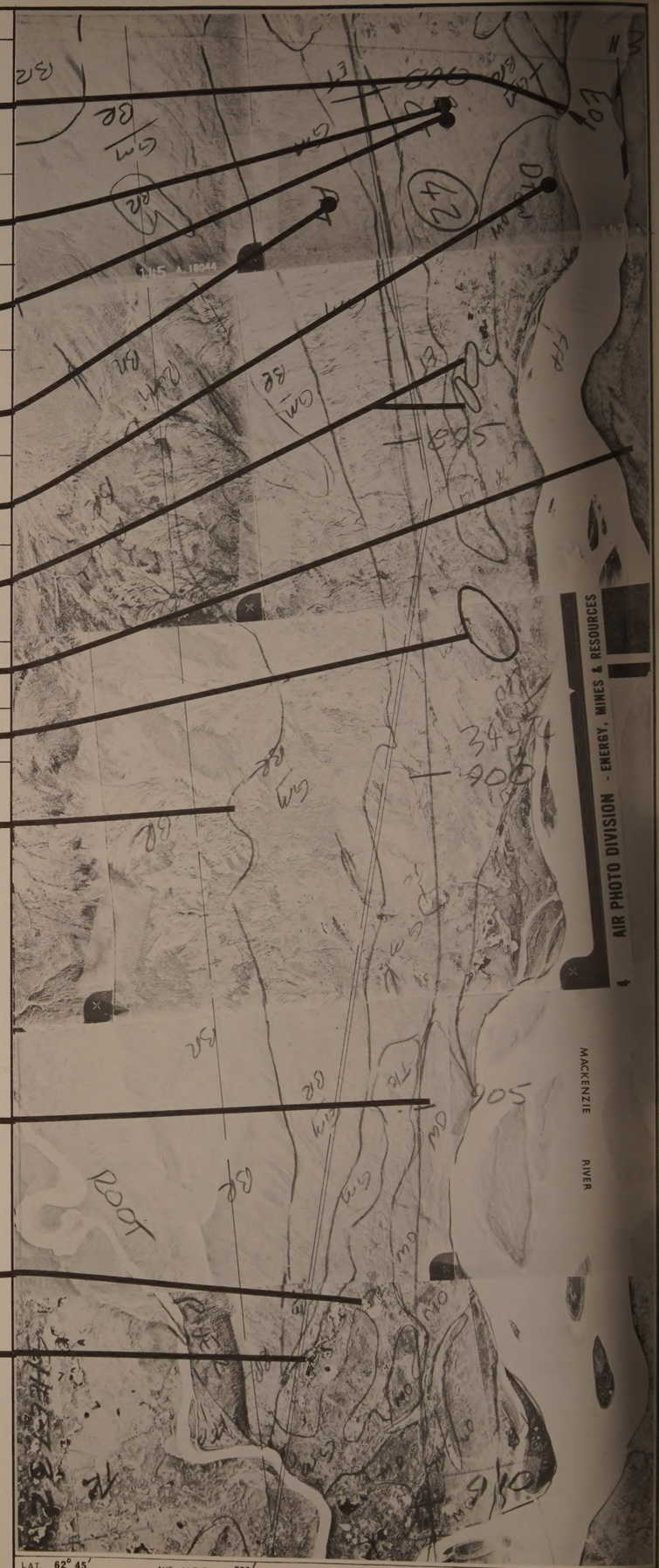
SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE
42 C_T	Dwarf birch, willows, and stunted tamarack; leatherleaf and moss in the area of the thermokarst pond. Surrounding the pond are moderate black spruce, birch and tamarack to 50' in height.	0 - 4' PEAT, frozen at 2', ice crystals (Vx) 4' - 30' SILT, sandy, ice crystals (Vx) to 9' depth, then no visible ice, (Nbn)
42 B_T	Dwarf birch, bearberry and labrador tea on the site. Light pines and a few white spruce to 15' in height with a heavy growth of birch to the south east.	0 - 2' ORGANIC 2' - 34' SILT and SAND, frozen at 2', ice crystals and lenses, (Vx, Vr), clayey with depth.
42 A_T	Moderate black and white spruce, tamarack and poplar to 20' with some to 50' in height. Some willow, dwarf birch, swamp laurel, labrador tea, lichen, grass and moss.	0 - 1' ORGANIC 1' - 22' SAND and GRAVEL, silty, (till-like), frozen below 3', ice crystals (Vx)
42 D_T	Heavy pines to 20' in height with some white spruce and birch to 25' in height and dwarf birch; fern moss, bearberry, labrador tea, swamp laurel and lichen.	0 - ¼' ORGANIC ¼' - 4½' SILT, sandy, loose, unfrozen 4½' - 20' SAND, very fine, silty, unfrozen

	RECONNAISSANCE OBSERVATION NOTES
42 E_0	Riverbank profile generally as sketched. Upper limit to beach marked by large water borne logs. Silt, sand and gravel (till) sample taken from top of bank shown in Picture 1. Picture 2 shows low bank of silty clay near river level at mouth of small creek.
42 C_T	Test hole adjacent to infilling thaw pond shown in Picture 3 together with its proximity to B_T.
42 B_T	Test hole on palsa plateau in TK as shown in Picture 4. Picture 5 taken from the top of the plateau overlooks site C_T and a palsa mound on the other side of the thaw pond.
42 A_T	Test hole in sheetwash shown in Picture 6 looking south.
42 D_T	Test hole in a natural clearing in outwash plain as shown in Picture 7. Picture 8 shows site from ground level.
	Ridges with jack pine to 40' in height. Timber in general area is mostly black spruce with some birch.
	Drumlinoidal ridge approximately 100' high and covered with birch.
	Series of dumlinoidal ridges in this area. There is an airstrip down the spine of one ridge.
42 F_0	Picture 9.
42 G_0	Picture 10 shows general area including TK thaw lakes.
42 H_0	Picture 11 shows general area including TK thaw lakes.
	Thaw banks in thermokarst lakes approximately 6' high.

NOTE: Tree Population

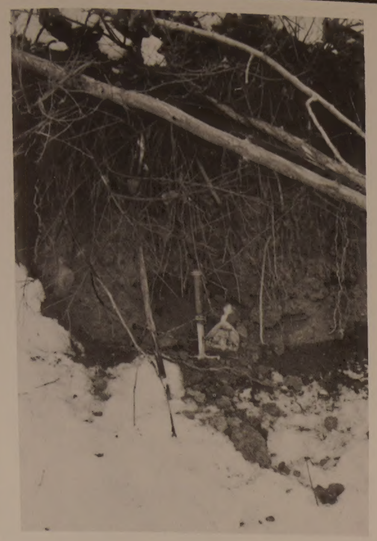
Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "



LAT. 62° 45'
LONG 123° 20'

AVE. ALTITUDE 500'
MEAN ANNUAL AIR TEMP. 24°F

SITE NO. 42 SHEET NO. 32
PLATE NO. 116



Picture: 1 Overhang near top of bank from which sample of till was taken.
Site: 42 E_0

Picture: 2 Silty clay bank of Mackenzie River just north of small creek.
Site: 42 E_0

Picture: 3 Test hole location showing proximity of site to B_T.
Site: 42 C_T

Picture: 4 Test hole location in TK terrain.
Site: 42 B_T

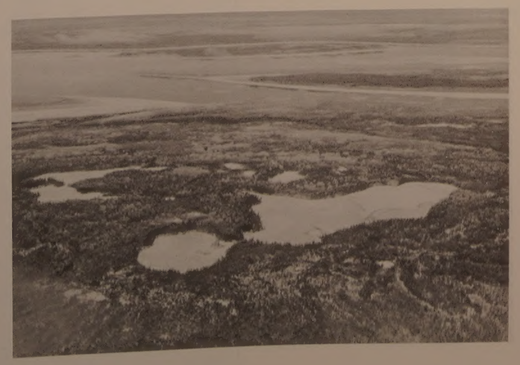
Picture: 5 View of drill on Site C_T from B_T on palsa.
Site: 42 B_T

Picture: 6 Looking south at test hole location.
Site: 42 A_T

Picture: 7 Test hole location on outwash plain adjacent to River.
Site: 42 D_T

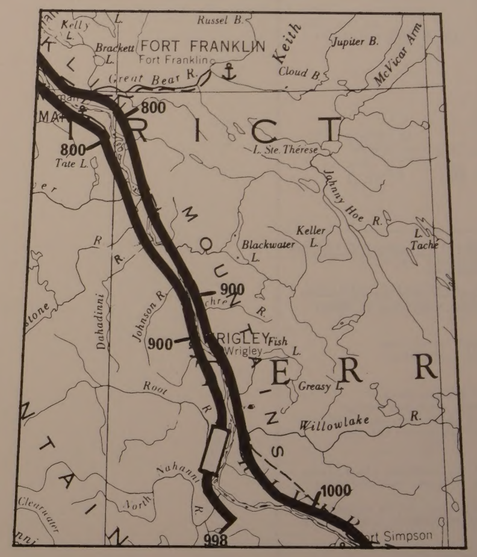
Picture: 8 View across test site toward trees surrounding the clearing.
Site: 42 D_T

Picture: 9 View looking west at topography in this area.
Site: 42 F_0



Picture: 10 View looking east over TK terrain toward Mackenzie River.
Site: 42 G_0

Picture: 11 View looking east over TK terrain toward Mackenzie River.
Site: 42 H_0



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Pictures taken in late October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE				
	TITLE: Photo Mosaic and Terrain Investigation MILE 947 TO MILE 968				
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: R Jewell	DATE: Dec/70	SITE No. 42	PLATE No. 117
	APPROVED: Curlpeer	DATE: Dec/70	SHEET No. 32	

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SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

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J. D. Mollard and Associates Limited

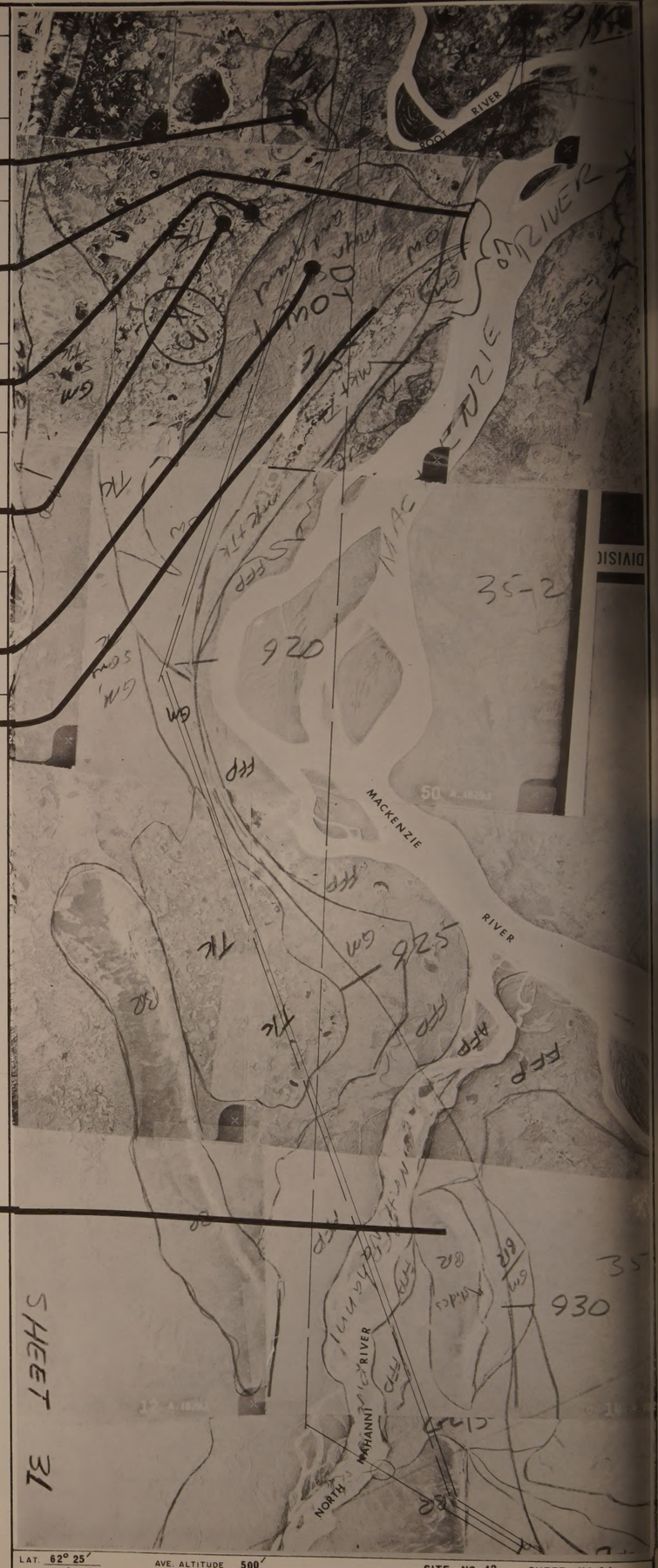
MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN
MK	Muskeg, swamp, marsh, bog; includes all unpatterned peatlands
TK	Thermokarst plains; pattern of thaw lakes, ponds and muskegs developed on thick ice-rich organic and inorganic waterlaid silt and fine sand
FFP	"Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel
AFP	Active flood plain; mainly exposed sand, gravel and cobbles with boulders locally
BR	Extensive bedrock outcrops on mountain slopes and thin soils over bedrock on steep slopes, often more subdued and subrounded in foothill regions
GM	Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt
OW	Glacial outwash; mainly sand and gravel with minor silt, often with thin silt mantle
AFD	Variable-textured alluvial fans; mainly thin silt over sand and gravel with major textural variations often inferrable from local geomorphic (depositional) setting

SEE PLATE No 3 for a comprehensive description of symbols.

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
43 A_T	Dense black spruce up to 15' in height with some dwarf birch; labrador tea, horsetail and moss. Taller, dense black spruce and birch farther out from test site.	0 - 2' ORGANIC, frozen below 2' 2' - 2½' ICE, silt lenses 2½' - 5' SILT, clayey, ice crystals and lenses (Vx, Vr) 5' - 22' SILT, sandy, (till-like), ice crystals and inclusions (Vx)	43 A_T Test hole located on spine of large drumlinoidal ridge.
			43 E_0 Observation of exposures on 1½ miles of riverbank, bounding both thermokarst terrain and outwash plain shown in Picture 1. Picture 2 shows close-up of a slide in the 150' high silt bank bordering the OW in which an occasional boulder was observed as shown in PIcture 3. Picture 4 is a close-up of the silt strata encountered. There was no apparent source of water in the slope. At the south end of the site, silty clay was encountered with a localized patch of boulders on the beach.
43 B_T	Dense black spruce, pines, tamarack and birch to 25', with some willows and dwarf birch; horsetail, bearberry, labrador tea and lichen.	0 - 2' ORGANIC 2' - 15' SILT and SAND, frozen below 2', ice crystals (Vx) 15' - 22' SAND, silty, ice crystals (Vx)	43 B_T Picture 5 shows test hole location in TK together with the peat thaw bank shown in Pictures 6 and 7. Test site vegetation is shown in Picture 8.
43 C_T	Moderate black spruce to 20' with pine, tamarack and a few black spruce to 40'. Labrador tea, moss, swamp laurel, bearberry, grass and horsetail. Tall dense black spruce on a hill 200 yds. to the southwest.	0 - 2' ORGANIC 2' - 5' SILT and SAND, frozen below 2', ice crystals and lenses (Vr, Vx) 5' - 27' SAND, silty, ice crystals (Vx), to 10' depth then no visible ice (Nbn) to 27' depth.	43 C_T Test hole located in TK as shown in Picture 9. Surface vegetation is shown in Picture 10.
43 D_T	Dense pines to 70' in height with a few birch and black spruce. Sone dwarf birch and rose bushes; lichen, bearberry and moss.	0 - 4" ORGANIC 4" - 21' SAND, very fine, loose, unfrozen. 21' - 22' SILT, sandy 22' - 32' SAND, silty, loose, unfrozen.	43 D_T Test hole in tall trees on level outwash plain shown in Picture 11. Picture 12 shows tree growth from ground level.
			43 F_0 Well-defined silt bank bordering TK and OW plain.
			43 G_0 Picture 13 shows stratified sediments dipping west in the Nahanni Range.

NOTE: Tree Population

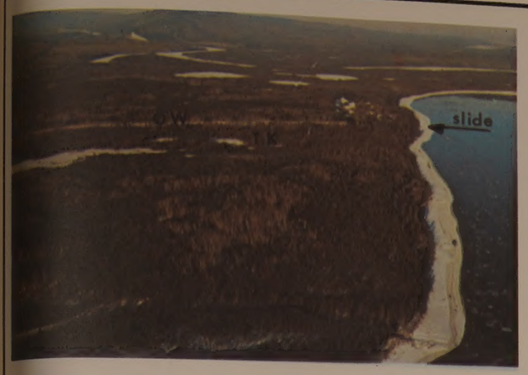
Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "



LAT. 62° 25′
LONG. 123° 20′

AVE. ALTITUDE 500′
MEAN ANNUAL AIR TEMP. 24°F

SITE NO. 43 SHEET NO. 31
PLATE NO. 118



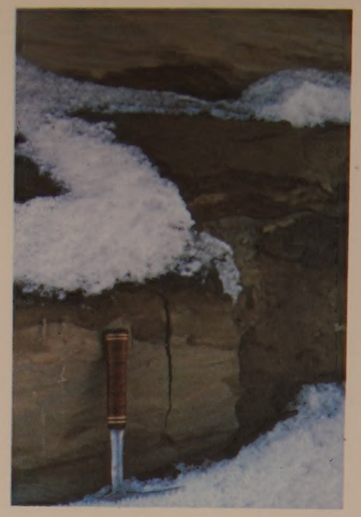
Picture: 1 West bank of the Mackenzie River bordering TK and OW terrain as indicated.
Site: 43 E_0

Picture: 2 Closer view of the slide indicated in Picture 1

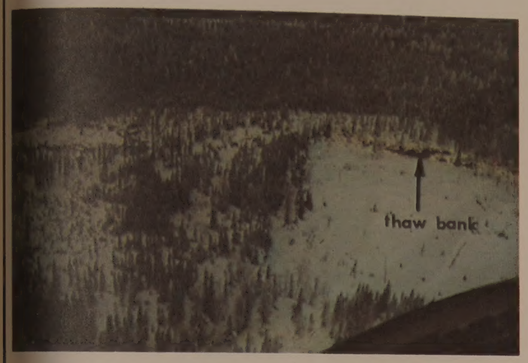
Picture: 3

Boulder in silt near river level at the bottom of the slide.

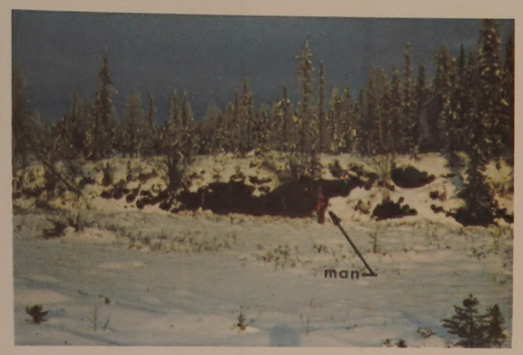
Site: 43 E_0



Picture: 4 Silt strata exposed at the top of the slide.
Site: 43 E_0



Picture: 5 Test hole location and exposed peat bank in thaw pond.
Site: 43 B_T



Picture: 6 Exposed peat bank in thaw pond.
Site: 43 B_T

Picture: 7

Close-up view of peat exposure in thaw pond.

Site: 43 B_T

Picture: 8 Looking west over test site toward Camsell Range.
Site: 43 B_T

Picture: 9 Test hole location adjacent to TK thaw pond.
Site: 43 C_T

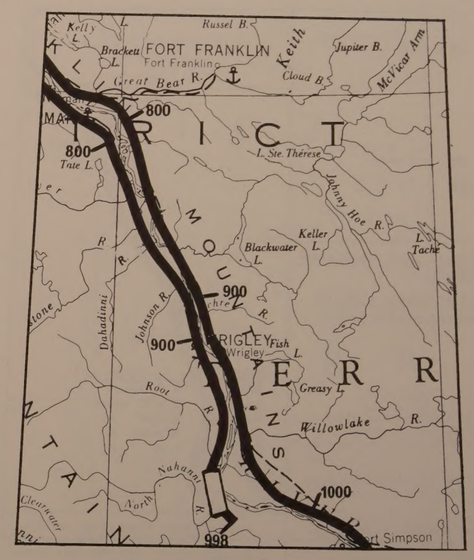
Picture: 10 View of vegetation adjacent to test site.
Site: 43 C_T

Picture: 11 Test site prior to final clean up.
Site: 43 D_T

Picture: 12 Close-up view of trees on test site.
Site: 43 D_T

Picture: 13
Site: 43 G_0

Looking south toward Lone Mountain and the Nahanni Range across the North Nahanni River.



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Pictures taken in early November, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE			
	TITLE: Photo Mosaic and Terrain Investigation MILE 968 TO MILE 990			
	SUBMITTED: L Jewell	DATE: Dec/70	SITE No.: 43	PLATE No.: 119
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	APPROVED: [illegible]	DATE: Dec/70	SHEET No.: 31	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED – NO EXCESS ICE

Nbe WELL BONDED – EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

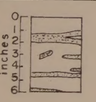
Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL – ICE –

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by–

J. D. Mollard and Associates Limited

MAP SYMBOL — ABBREVIATED DESCRIPTION OF TERRAIN

GM – Level to gently rolling ground moraine; mainly compact "basal" till, often with thin fine sand, silt or silty clay mantle locally

FFP – "Fossil" (i.e., inactive) flood plain; mainly thin silt over sand and gravel

TK – Thermokarst plains; pattern of thaw lakes, ponds and muskegs, developed in thick ice-rich organic and inorganic waterlaid silt and fine sand

GLB – Thick glacial-lake materials; mainly ice-rich silt and fine sand with minor clay

ET – Gently to moderately sloping water-eroded (sheet erosion) till or bedrock plain; mainly thin ice-rich silt or sand mantle over till or bedrock

→ Drumlinized and/or fluted surface; mainly isolated patches of silt over thin till over bedrock or over fluted bedrock

SEE PLATE No 3 for a comprehensive description of symbols.

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

This area is poorly drained TK.

Grass-infill to edge of treed island.

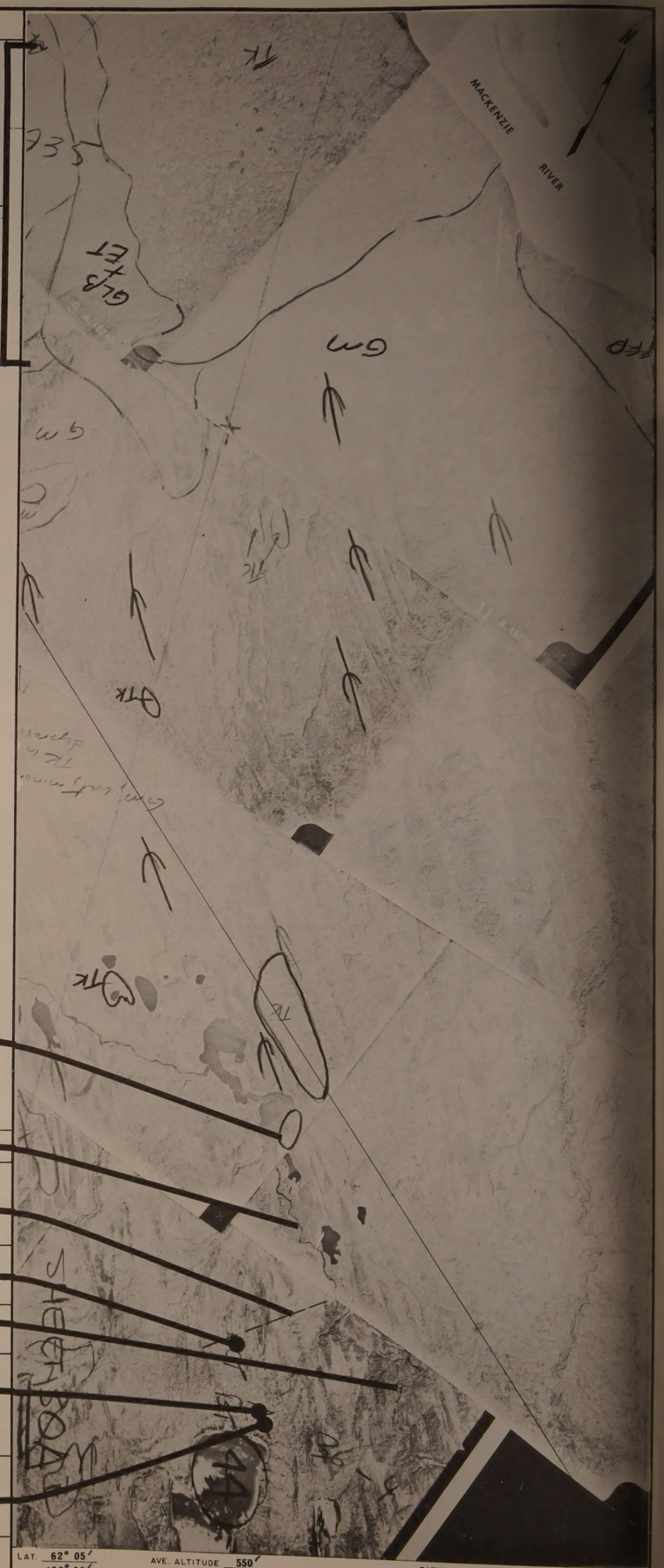
Lakes joined and drained by active river shown. Valley slopes gently to river elevation some 100' below the general plain.

Seismic cutline.

44 C_T	Heavy black spruce and pines to 30' in height with some dwarf birch. Labrador tea, horsetail, lichen and moss.	0 - 2' 2' - 22'	ORGANIC SAND, silty, clayey, (till-like)	44 C_T	Test hole on low ridge shown in Picture 1. Ridge height is of the order of 4' above surrounding level.

Picture 2 showing general topography and vegetation in TK area.

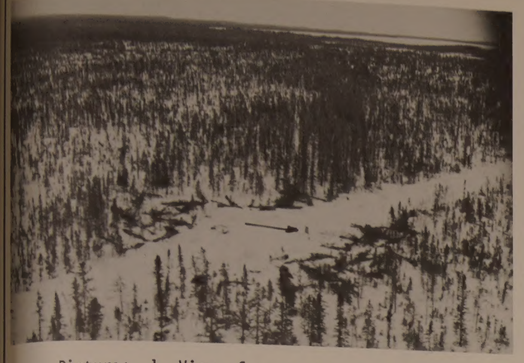
44 B_T	Heavy black spruce to 30' in height, with a few willows; bearberry, labrador tea, leatherleaf and lichen.	0 - 10' 10' - 20' 20' - 27'	PEAT, frozen below 2', ice crystals (Vx) CLAY, silty, 20% ice in crystals and inclusions (Vx) SAND, silty, clayey, (till-like), ice crystals (Vx)	44 B_T	Test hole in slightly better drained area of palsa bog. Picture 3 shows proximity at A_T and B_T as well as surface conditions.
44 A_T	Sparse black spruce to 15' in height, and a few stunted tamaracks; labrador tea, swamp laurel and leatherleaf.	0 - 19' 19' - 20' 20' - 24½'	PEAT, very soft, unfrozen SILT, soft SILT, CLAY, SAND, (till-like)	44 A_T	Test hole in palsa bog as indicated in Picture 3.



LAT. 62° 05'
LONG 123° 00'

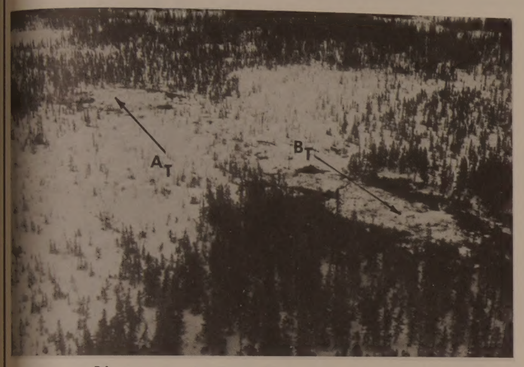
AVE. ALTITUDE 550'
MEAN ANNUAL AIR TEMP. 24°F

SITE NO. 44 SHEET NO. 30A
PLATE NO. 120



Picture: 1 View of test site on low ridge prior to clean up. Ridge is oriented N-S and is typical of several in the area.
Site: $44C_T$

Picture: 2 View looking north east from the test site area.
Site: 44



Picture: 3 Test hole locations in palsa bog. Area between sites is very wet.
Site: 44
A_T, B_T

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Pictures taken in early November, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 990 TO MILE 1010 OFFSET

SUBMITTED	DATE	SITE No.	PLATE No.
L. Jewell	Dec/70	44	121
APPROVED	DATE	SHEET No.	
	Dec/70	30A	

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J.C. Sproule and Associates Ltd.
for
MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED
in 1969

LEGEND

MAP UNITS

QUATERNARY or HOLOCENE
- Q — Quaternary Undivided
- Qs — Slump
- Qal — Recent Alluvium
- Qt — Terrace
- Qm — Moraine
- Qe — Esker

DESCRIPTIVE ABBREVIATIONS

QUATERNARY or HOLOCENE (UNCONSOLIDATED)
- Gr — Gravel
- Sd — Sand
- Slt — Silt
- Cl — Clay
- Pt — Peat
- Ti — Till

PALEOZOIC — TERTIARY (BEDROCK)
- Fel — Felsenmeer (rock rubble nearly in situ)
- Cgl — Conglomerate
- Ss — Sandstone
- Sltst — Siltstone
- Sh — Shale
- Ca — Carbonate

Note. Coarser or finer material listed first, depending upon which is believed to be more abundant.

SYMBOLS

Fault, F—major, f—minor; U—upthrown, D—downthrown side; arrows indicate direction of apparent horizontal movement — Defined / Approximate / Assumed

Raised beach or wave-cut terrace

Drainage, emphasized to show pattern

Quaternary boundary

Extensive Muskeg or Swamp

2080 ● Test Hole Location 1969

Proposed Pipeline Route 1969

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
49 A_T	Light spruce and tamarack to 20'; occasional birch, labrador tea, lichen.	0 - 4½' PEAT, frozen below 2', no visible ice (Nbn) 4½' -21½' SAND, fine, silty, no visible ice, (Nbn)	49 A_T Test hole located adjacent to seismic cut line in TK terrain. Picture 1 shows surface vegetation in the area.
49 B_T	Light spruce to 15' in height; occasional tamarack, labrador tea and lichen on peat mounds.	0 - 5' PEAT, frozen below 2½', occasional ice crystals (Vx) 5' - 21' SAND, fine, silty, ice lenses (Vr)	49 B_T Test hole located in TK area adjacent to the thaw pond shown in Pictures 2 and 3. The pond level is 2' below surrounding ground level. Frost was not encountered within 4½' of pond's surface. The test hole was situated in a burned out area approximately one quarter mile in diameter.
49 C_T	Light spruce to 15'; occasional tamarack, labrador tea, lichen and moss.	0 - 8' PEAT, frozen below 2', ice crystals (Vx) 8' -20½' SAND and SILT, ice lenses (Vr) to 15' depth then no visible ice (Nbn)	49 C_T Test hole located adjacent to an infilling TK thaw pond as shown in Pictures 4 and 5. The pond is 3' below surrounding ground level. Frost was not encountered within 5' of pond's surface.

Treed island and grass-infill.

Line AA (Sans Sault) investigated as possible test loop location.

Grass island.

Grass-infill and treed islands.

Small grass islands.

Line CC (Sans Sault) investigated as possible test loop location.

Line BB (Sans Sault) investigated as possible test loop location.

Grass-infilling from east with treed island.

Grass-infilling lake.

Slumping along 20' to 30' high clay and shale bank.

Extensive gravel deposits.

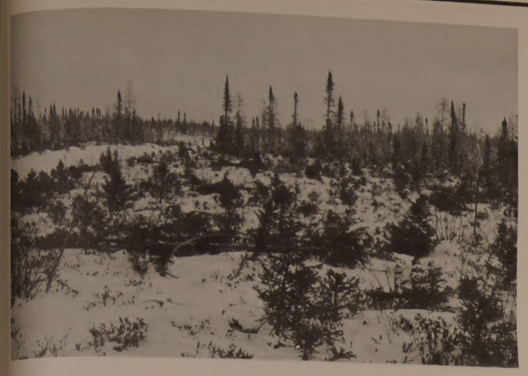
Rock exposure dips towards north west.

Grass-infill.

Grass-infill with spruce to 20' in height.

Extensive burn on ridges.

Qm-Sd,Cl,Pt
Qm-Sd,Cl
Qm-Sd,Cl,Pt
Qm-Sd,Cl,Pt
Qm-Sd,Cl,Pt



Picture: 1 View of vegetation on test site.

Site: 49 A_T

Picture: 2 View across test site to thaw pond.

Site: 49 B_T

Picture: 3 Infilling TK thaw pond near test site.

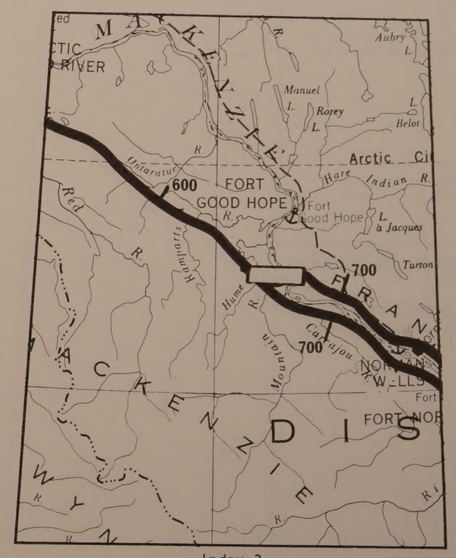
Site: 49 B_T

Picture: 4 View of thaw ponds from test site.

Site: 49 C_T

Picture: 5 Test hole location.

Site: 49 C_T



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Pictures taken in early October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE
	TITLE: Photo Mosaic and Terrain Investigation MILE 652 TO MILE 680
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: R Jewell DATE: Dec/70 SITE No.: 49 PLATE No.: 123
	APPROVED: DATE: Dec/70 SHEET No.: 29R

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Ndn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ICE-

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J. D. Mollard and Associates Limited

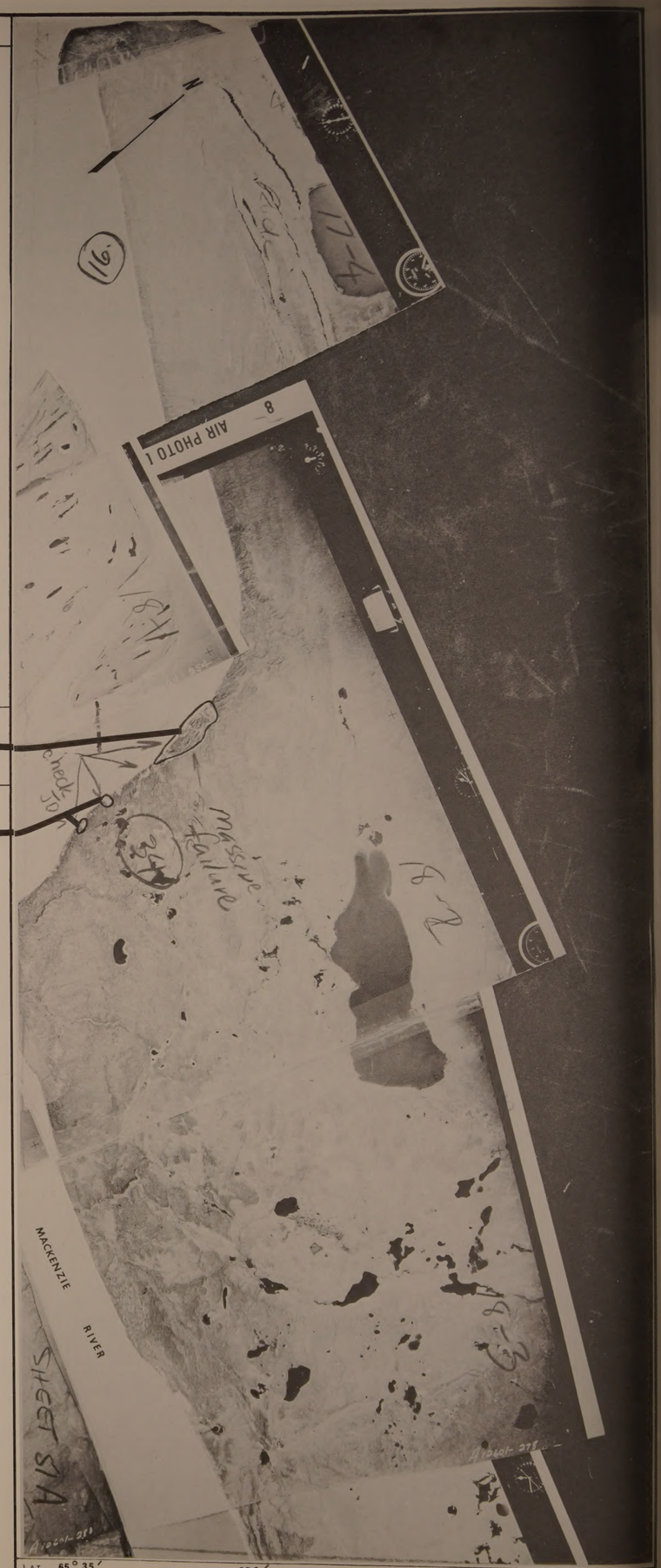
MAP SYMBOL	ABBREVIATED DESCRIPTION OF TERRAIN

Mosaic not annotated

SEE PLATE No 3 for a comprehensive description of symbols.

34 A_0 Pictures 1 and 2 show extensive sliding on bank of Mackenzie River. Pictures 3 and 4 show an exposure of sand and gravel in the slide from which seepage was evident as shown in Pictures 5 and 6. A sample was identified as being a poorly graded, fine calcareous greywacke sand with minor gravel inclusions. The trees on the slope as shown in Pictures 7 and 8 indicate that continued movements are occurring.

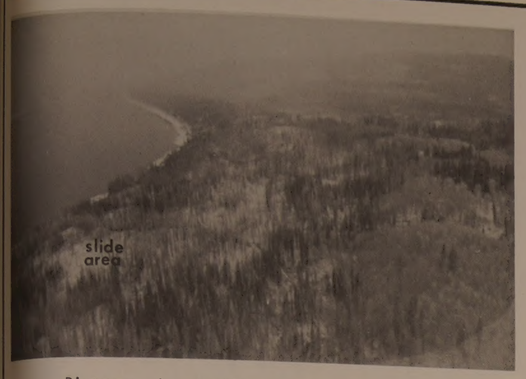
34 B_0 These areas showed further slides with sand exposures.



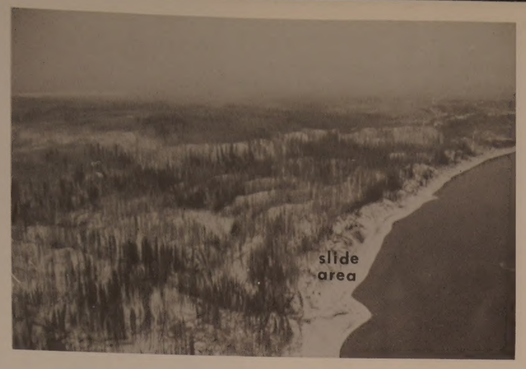
LAT. 65° 35′
LONG 128° 45′

AVE. ALTITUDE 350′
MEAN ANNUAL AIR TEMP. 20° F

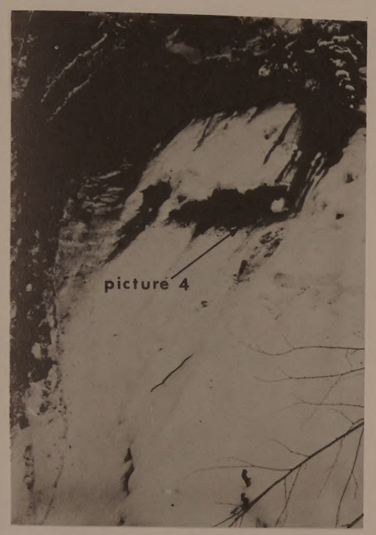
SITE NO. 34 SHEET NO. 51A
PLATE NO. 124



Picture: 1 Looking north at slide on east bank of Mackenzie River.
Site: 34 A_0



Picture: 2 Looking south at slide on east bank of Mackenzie River.
Site: 34 A_0



Picture: 3 Exposed face of sand and gravel.
Site: 34 A_0

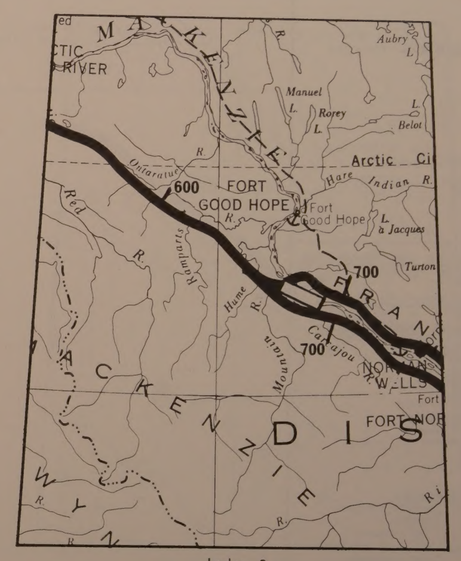
Picture: 4 Close-up of sand and gravel exposure.
Site: 34 A_0

Picture: 5 Seepage from top of bank in slide.
Site: 34 A_0

Picture: 6 Seepage at toe of bank shown in Pictures 3 and 5.
Site: 34 A_0

Picture: 7 Trees tilted as a result of continued movement in the area. Spruce and willow are 15' to 20' high.
Site: 43

Picture: 8 Trees tilted as a result of continued movement in the area. Spruce and willow are 15' to 20' high.
Site: 43



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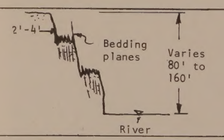
Pictures taken in early October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE				
	TITLE: Photo Mosaic and Terrain Investigation MILE 671 TO MILE 688 OFFSET				
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: R Jewell	DATE: Dec/70	SITE No.: 34	PLATE No.: 125
	APPROVED: Carlson	DATE: Dec 70	SHEET No.: 51A	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
SEGREGATED ICE NOT VISIBLE BY EYE				
Nf POORLY BONDED				Grass-infilling and treed island.
Nbn WELL BONDED — NO EXCESS ICE				Limestone cliffs, bedding planes dip steeply.
Nbe WELL BONDED — EXCESS ICE				Grass-infilling on north west bank.
				50' high ridge.
VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK				
Vx INDIVIDUAL ICE INCLUSIONS				30' high bank undercut by creek.
Vc ICE COATINGS ON PARTICLES				Lake is grass-infilling all round.
Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS				Small stream is grass-infilling.
Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS				Small esker-like ridge.
				Severe burn on ridge.
VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK				
ICE & SOIL ICE WITH SOIL INCLUSIONS	50 A_T	Hummocky ground, old burn area, no surface vegetation left after fire except for burned out grass tussocks.	0 - 8' PEAT, frozen below 2', ice crystals (Vx) 8' - 18' SILT, sandy, ice crystals and lenses (Vx, Vr) 18' -20½' SAND, fine, clean, no visible ice, (Nbn) 20½' -21½' SILT, clayey, ice lenses (Vr)	50 A_T Test hole located in a recent burn area in TK terrain 500' west of the lake shown in Picture 1. Picture 2 is a general view across the test site.
ICE ICE WITHOUT SOIL INCLUSIONS	50 C_T	Moderate willows to 2' in height. Labrador tea and grass.	0 - 17' SAND, fine to medium, silty, unfrozen.	50 C_T Test hole located on a neck of land separating two lakes in TK terrain as shown in Picture 3. Site is only 1' above lake level and has been recently burned.
LEGEND: SOIL — ICE —	50 B_T	Heavy spruce to 35' on crest of ridge. Light birch and willows down slope.	0 -21½' SAND, fine to coarse, silty, frozen below 6', no visible ice (Nbn).	50 B_T Test hole located on a 20' high ridge separating two lakes as shown in Picture 4. Picture 5 looks east from the test site over one of the lakes.
	50 D_0	Near vertical bedding in limestone exposure as shown in Picture 6. The bank height along this section varied from 80' to 160'. Fossils were evident in the limestone.		
				Treed islands in lake.
				Surface flow slides on 60' high bank.
				Skin slide on steep 70' high ridge.
				Minor flow slide activity.
				Birch prominent in this area.
				Small flow slide along steep 60' high bank.

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J.C. Sproule and Associates Ltd.
for
MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED
in 1969

LEGEND

MAP UNITS

QUATERNARY or HOLOCENE
- Q — Quaternary Undivided
- Qs — Slump
- Qal — Recent Alluvium
- Qt — Terrace
- Qm — Moraine
- Qe — Esker

DESCRIPTIVE ABBREVIATIONS

QUATERNARY or HOLOCENE (UNCONSOLIDATED)	PALEOZOIC — TERTIARY (BEDROCK)
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Slt — Silt	Ss — Sandstone
Cl — Clay	Siltst — Siltstone
Pt — Peat	Sh — Shale
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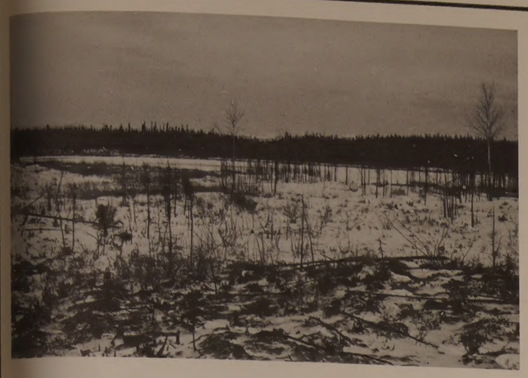
SYMBOLS

- Fault, F — major, f — minor; U — upthrown, D — downthrown side, arrows indicate direction of apparent horizontal movement — Defined / Approximate / Assumed
- Raised beach or wave-cut terrace
- Drainage, emphasized to show pattern
- Quaternary boundary
- Extensive Muskeg or Swamp
- 2080 Test Hole Location 1969
- Proposed Pipeline Route 1969

NOTE: Tree Population

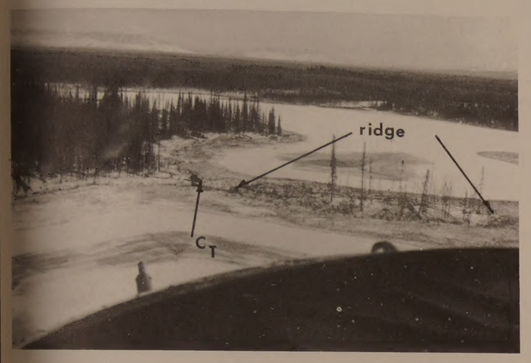
Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

MACKENZIE RIVER
Qm-Sl Pl
Qm-Gl Sh
Qm-Sl Cl Pt
Qm-Sl Cl Pt



Picture: 1 General view looking east toward thaw pond.
Site: 50 A_T

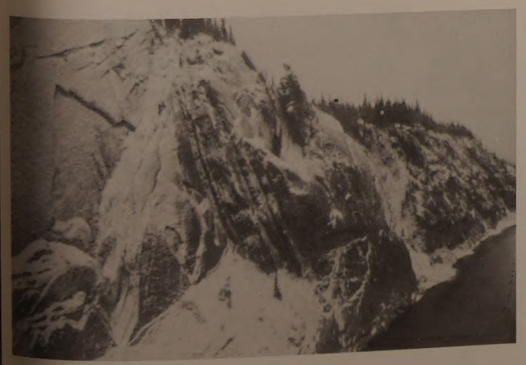
Picture: 2 View across test site in burnt out area.
Site: 50 A_T



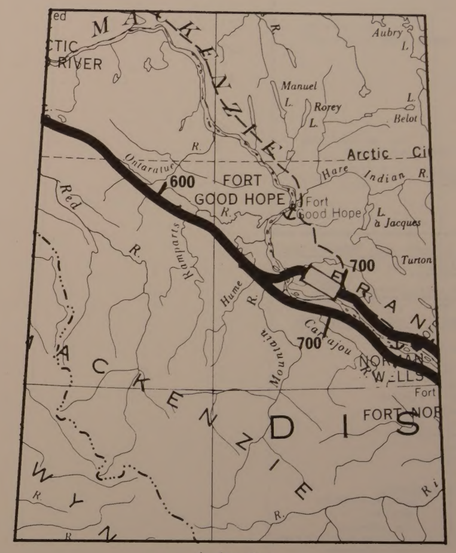
Picture: 3 Test hole location between two lakes. Note 10' high dune-like ridge to the right of the site.
Site: 50 C_T

Picture: 4 View of test site on ridge separating lakes.
Site: 50 B_T

Picture: 5 View from test site over the lake in the background.
Site: 50 B_T



Picture: 6 Near vertical bedding of 150' high limestone exposure on east bank of Mackenzie River near Site 50.
Site: 50 D_O



Index 3

Pictures taken in early October, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER EDMONTON CALGARY REGINA WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 675 TO MILE 700

SUBMITTED	DATE	SITE No.	PLATE No.
R Jewell	Dec/70	50	127
APPROVED	DATE	SHEET No.	
Gus Spleer	Dec/70	29 P	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
				Stream and lakes are grass-infilling.
				River bank profile of wide beaches and banks sloping at approximately 4 horizontal to 1 vertical.
				Sand ridges similar to 51 A_0.
				Willows to 4' on FFP.
				Bank sloughing and undercutting at high water levels.
				Sand dune.
	51 A_0			The 75' high bank shown in Picture 1 is typical of several in the area. Picture 2 shows the medium grained greywacke sand in the bank at the location indicated in Picture 1.
	51 B_0			60' high bank shown in Picture 3 exposed sand and silt materials.
				Similar silt and fine sand banks as shown in Picture 3.
				Creek is grass-infilled.
				Recent flow slide on top of ridge.
				75' high banks slope at approximately 1 horizontal to 2 vertical. Some flow slides in drainage paths.
				Meandering stream. Minor undercutting of banks observed.
				60' high steep limestone bank.
	52 A_0			A 60' high river bank of silty clay sloping at approximately 45° with minor slumping occurring as shown in Picture 4. Gravel samples recovered from deposits on the lower sections of the bank were identified as medium-grained quartzite.
				Small ridge.
				Low banks.
				Grass-infill all round lake.
				Gravel bar.

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J.C. Sproule and Associates Ltd.
for
MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED
in 1969

LEGEND

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Note. Coarser or finer material listed first, depending upon which is believed to be more abundant.

SYMBOLS

Fault, F—major, f—minor; U—upthrown, D—downthrown side; arrows indicate direction of apparent horizontal movement — Defined / Approximate / Assumed

Raised beach or wave-cut terrace

Drainage, emphasized to show pattern

Quaternary boundary

Extensive Muskeg or Swamp

209 ● Test Hole Location 1969

Proposed Pipeline Route 1969

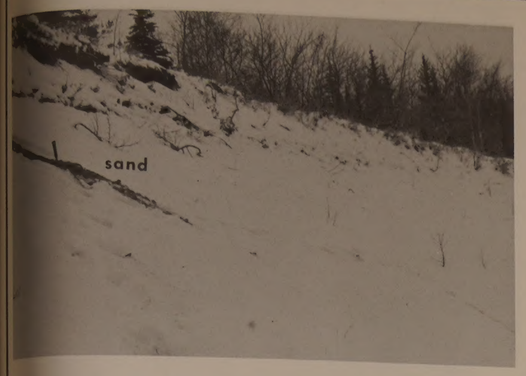
NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

LAT. 65° 35′
LONG. 127° 45′

AVE. ALTITUDE 250′
MEAN ANNUAL AIR TEMP. 21°F

SITE NO. 51&52 SHEET NO. 29N
PLATE NO. 128



Picture: 1 General view of top section of bank.

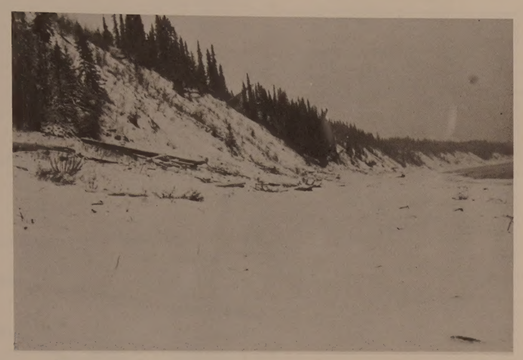
Site: 51 A_0

Picture: 2 Close-up of sand exposed in bank in location shown in Picture 1.

Site: 51 A_0

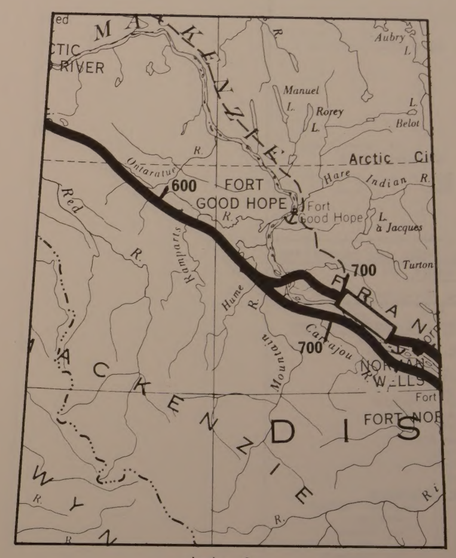
Picture: 3 Steep silt and sand bank.

Site: 51 B_0



Picture: 4 Bank on east side of Mackenzie River. Note leaning trees in mid-picture, signifying recent sliding.

Site: 52 A_0



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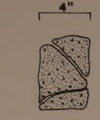
Pictures taken in early October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE				
	TITLE: Photo Mosaic and Terrain Investigation MILE 700 TO MILE 728				
	SUBMITTED: L Jewell	DATE: Dec 170	SITE No.: 51&52	PLATE No.: 129
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	APPROVED: Endpeer	DATE: Dec/70	SHEET No.: 29 N	

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

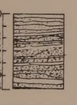
Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

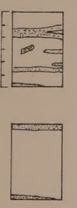
Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS



Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ICE-

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J.C. Sproule and Associates Ltd.
for
MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED
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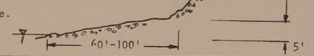
U—upthrown, D—downthrown side; arrows indicate direction of apparent horizontal movement

Raised beach or wave-cut terrace
Drainage, emphasized to show pattern
Quaternary boundary
Extensive Muskeg or Swamp
2080 ● Test Hole Location 1969
Proposed Pipeline Route 1969

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
			Small flow slide on 60' high river bank.
			Grass-infilling at south east end of lake.
			Minor flow slides on 40' high bank on west side of river.
			Small slide caused by undercutting by creek entering Mackenzie River.
			Moderate spruce cover generally to 20' in height with occasional trees to 40' in height.
53 D_T	Sparse tamarack to 10', small willows and labrador tea.	0 - 1' ORGANIC 1' - 9' SILT, clayey, frozen below 2½', ice crystals (Vx) 9' -20½' SAND and SILT, gravelly, (till-like), few ice crystals (Vx)	53 D_T Test hole on gently sloping sparsely vegetated ground as is shown in Picture 1.
53 B_T	On seismic cut line, there are occasional small willows, and grass. Adjacent to the site are dense black spruce and occasional tamarack to 15' in height; small willow, labrador tea and moss.	0 - 1' ORGANIC 1' - 15' SILT, organic, clayey, frozen at 19", ice crystals and lenses (Vx, Vr), pieces of shale below 10' depth.	53 B_T Test hole located on a seismic line on the terrace shown in Picture 2 Picture 3 from the seismic line shows the trees adjacent to the site below which the frost depth was 18".
53 C_T	On seismic cut line, there are occasional willows and grass.	0 -21½' SILT, clayey, frozen below 40", ice crystals (Vx) shale fragments and ice lenses (Vr) below 15' depth.	53 C_T Test hole on seismic line in TK terrain shown in Picture 4 Probing in the trees adjacent to the hole indicated frost at the 3' depth.
			53 A_0 Deposits of gravel, cobbles and boulders in 20' high river bank as shown in Pictures 5 and 6 Rock samples were identified as syenite and quartzose sandstone.



53 E_0	Sand, gravel and cobble deposits in creek bed. The 4' high banks as shown in Picture 7 are of clean, medium grained sand.

Location of areas investigated for possible Norman Wells test loop site.

Limestone quarry which has a shale overburden up to 3½' thick.

Lakes generally well-defined in area of medium to heavy spruce.

Treed island in grass-infilling lake.

Muskeg areas around lake.

60' high active thaw bank.

Esker-like ridge.

LAT. 65° 20'
LONG 126° 50'

AVE. ALTITUDE 300'
MEAN ANNUAL AIR TEMP. 21°F

SITE NO. 53 SHEET NO. 29M
PLATE NO. 130

Picture: 1 View looking north from test site.
Site: 53 D_T

Picture: 2 View looking north west at site and Mackenzie River.
Site: 53 B_T

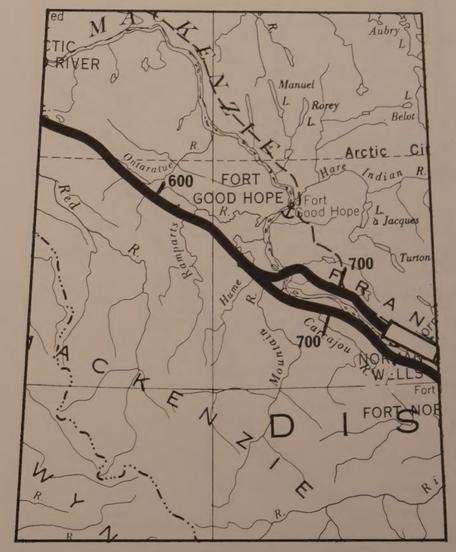
Picture: 3 View from site looking north west along seismic line.
Site: 53 B_T

Picture: 4 View along seismic line looking north east.
Site: 53 C_T

Picture: 5 Gravel, cobble and boulder deposit on 20' high river bank. Note shovel.
Site: 53 A_0

Picture: 6 Close-up of gravel bank in Picture 5.
Site: 53 A_0

Picture: 7 View of Bosworth creek looking south toward, Norman Wells.
Site: 53 E_0



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Pictures taken in early October, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 727 TO MILE 752

SUBMITTED	DATE	SITE No.	PLATE No.
L Jewell	Dec/70	53	131
APPROVED	DATE	SHEET No.	
Cooper	Dec/70	29M	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

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ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

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2080 Test Hole Location 1969

Proposed Pipeline Route 1969

NOTE: Tree Population

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Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

Esker-like ridge.

Eroded watercourse 30' deep.

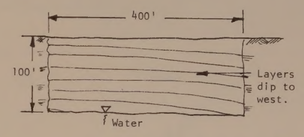
Grass-infilling lakes.

Outwash area of sand and gravel covered with grass.

Old creek bed has infilled with grass.

Esker-like ridge with poplar and willow to 30' in height.

54 A_0 Sink hole 400' x 200' x 100' deep shown in Picture 1 has strata as in Picture 2 dipping to the west. A visual assessment indicated that alternate layers of limestone and sandstone made up the walls of the sink hole. Pictures 3, 4, and 5 show other views of the exposed strata.



Exposures along Vermillion creek show layered strata believed to be shale and limestone in the 50' to 60' high banks. The layers average 18" to 2' thick. There were extensive gravel deposits in the river bed.

The sink hole indicated contains a lake with its surface near ground level.

Pictures 6 and 7 show small sink holes on the locations indicated on the mosaic. These depressions are shaped like an inverted cone and do not exceed 40' deep. Spruce to 30' in height grow in and around the holes as shown in the pictures.

Esker-like ridges.

Well-defined lake at base of 150' high ridge.

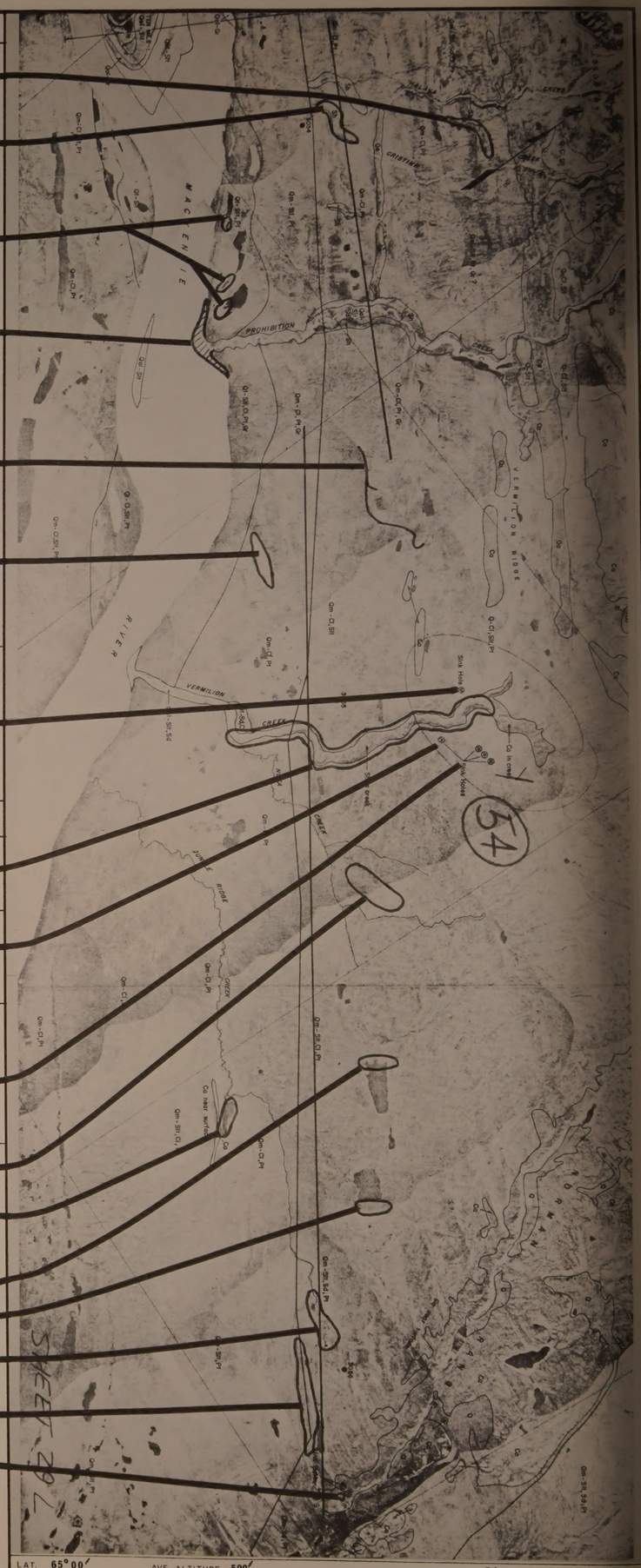
Lake is grass and tree infilling at northern end.

String bog.

Infilling thermokarst and string bog terrain.

Creek is grass-infilling.

Appears to be third sink hole forming.



LAT. 65° 00'
LONG 125° 45'

AVE. ALTITUDE 500'
MEAN ANNUAL AIR TEMP. 21° F

SITE NO. 54 SHEET NO. 29
PLATE NO. 132

Picture: 1 100' deep sink hole on north side of Vermillion Creek.
Site 54 A_0

Picture: 2 View of sink hole walls showing strata dipping west.
Site: 54 A_0

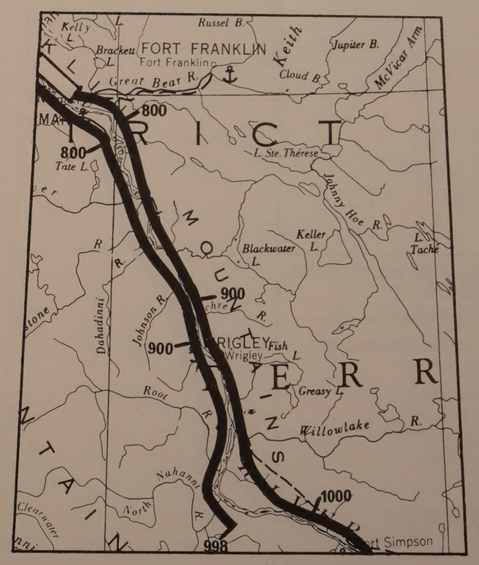
Picture: 3 Walls of sink hole. Man at top indicates magnitude of hole.
Site: 54 A_0

Picture: 4 View of sink hole walls showing seepage.
Site: 54 A_0

Picture: 5 Shows seepage from sink hole walls.
Site: 54 A_0

Picture: 6 Small sink holes south of Vermillion Creek.
Site: 54 A_0

Picture: 7 Small sink holes south of Vermillion Creek.
Site: 54 A_0



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Pictures taken in early October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE			
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	TITLE: Photo Mosaic and Terrain Investigation MILE 752 TO MILE 778			
	SUBMITTED: R Jewell	DATE: Dec/10	SITE No. 54	PLATE No. 133
	APPROVED: [illegible]	DATE: Dec/70	SHEET No. 29 L	

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

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Nde WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

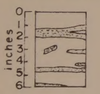
Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

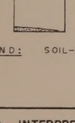
Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS



ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J.C. Sproule and Associates Ltd.
for
MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED
in 1969

LEGEND

MAP UNITS

QUATERNARY or HOLOCENE
- Q — Quaternary Undivided
- Qs — Slump
- Qal — Recent Alluvium
- Qt — Terrace
- Qm — Moraine
- Qe — Esker

DESCRIPTIVE ABBREVIATIONS

QUATERNARY or HOLOCENE (UNCONSOLIDATED)	PALEOZOIC — TERTIARY (BEDROCK)
Gr — Gravel	Fel — Felsenmeer (rock rubble nearly in situ)
Sd — Sand	Cgl — Conglomerate
Slt — Silt	Ss — Sandstone
Cl — Clay	Sltst — Siltstone
Pt — Peat	Sh — Shale
Ti — Till	Ca — Carbonate

Note. Coarser or finer material listed first, depending upon which is believed to be more abundant.

SYMBOLS

Fault, F — major, f — minor; U — upthrown, D — downthrown side; arrows indicate direction of apparent horizontal movement — Defined / Approximate / Assumed

Raised beach or wave-cut terrace

Drainage, emphasized to show pattern

Quaternary boundary

Extensive Muskeg or Swamp

2080 Test Hole Location 1969

Proposed Pipeline Route 1969

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE
55 B_T	Dense black spruce and occasional tamarack to 30' in height; labrador tea, lichen and moss.	0 - 1' ORGANIC 1' - 5' SAND and SILT, loosely frozen below 1½', (Nf) 5' -20½' SAND, silty, no visible ice (Nbn).

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

RECONNAISSANCE OBSERVATION NOTES

Extensive dune-like ridges.

Grass-infilling lake.

Lakes have well-defined banks in area of heavy spruce up to 60' high.

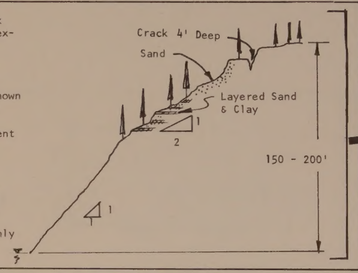
Great Bear River has relatively stable banks. Extensive gravel deposits evident in river bed and on banks.

Old flow slide.

Lake is grass-infilling on east.

55 B_T Test hole located 300' south of the Great Bear River on the site shown in Picture 1. Picture 2 is a close-up view of the site vegetation.

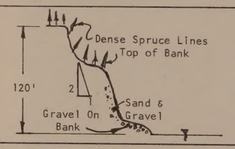
55 A_0 On 150' to 200' high river bank as sketched. Picture 3 shows exposed face of a slide in the top 60' of the bank. 30' back from the top of the bank is a large crack approximately 300' long and up to 2' wide as is shown in Picture 4. The crack depth was measured down to 4' and there was a vertical displacement across the crack of 1' to 2'. Samples taken inside the crack were identified as sandy silt. At the mid-height of the bank there was an exposure of layered sand and clay as shown in Picture 5 but the material in the slide appears to be mainly sandy silt.



Steep 60' high sand banks.

Old flow slide on banks of FFP.

55 C_01 Steep river bank, 120' high, with slumping occurring over a 60' high sand and gravel bank. The bank as sketched is shown in the background of Picture 6.



55 C_02 Flow slides in 100' high river bank as shown in Pictures 6 and 7. Bank below navigation marker showed sand and gravel.

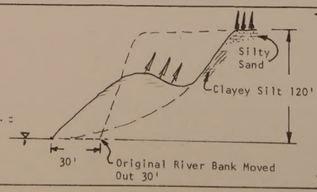
Sand and gravel deposits in outwash plain at mouth of small drainage channel.

55 C_03 Small slide in decomposed shale beneath thin silt cover shown in Picture 8.

Grass-infilled drainage path.

Channel is grass-infilling.

55 C_04 Old slide in 120' high river bank as sketched and shown in Picture 9. A thin layer of sandy silt overlies a low plastic clayey silt. Sand and gravel deposits were observed at the toe of the slope.



Minor slides along bank.

Grass-infill on many lakes in this area.

GREAT BEAR RIVER
FOUR MILE
Qm-Sl/Cl,Pt
Qm-Cl,Slt,Pt
Qm-Slt,Pt
Qm-Sl/Sd,Pt
Qm-Sl,Cl,Pt
Qm-Sh,Cl,Pt
Qm-Sh,Pt
Qm-Sl/Cl,Pt
Qm-Sl/Sd,Pt
Qm-Sl,Pt
Qm-Sl/Cl,Pt
Qm-Sl

Picture: 1 View of trees at test site.

Site: 55 B_T

Picture: 2 Close-up view of surface at test site.

Site: 55 B_T

Picture: 3 River bank slide on Great Bear River.

Site: 55 A_0

Picture: 4 Close-up of crack 30' back from top of river bank slide shown in Picture 3.

Site: 55 A_0

Picture: 5 Sand and clay strata encountered at mid-height of river bank shown in Picture 3. Note cobble in clay in upper left corner.

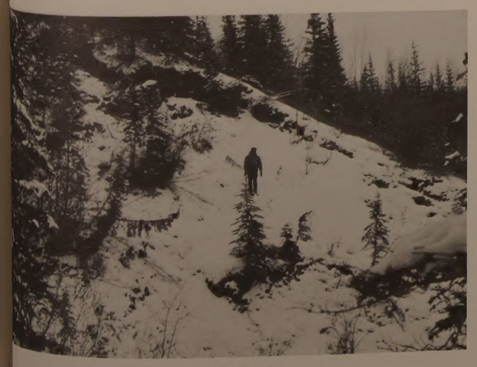
Site: 55 A_0

Picture: 6 View of slides along section of bank of Mackenzie River.

Site: 55 $C_0$1,2

Picture: 7 View of slides as in Picture 6, looking south.

Site: 55$C_0$2

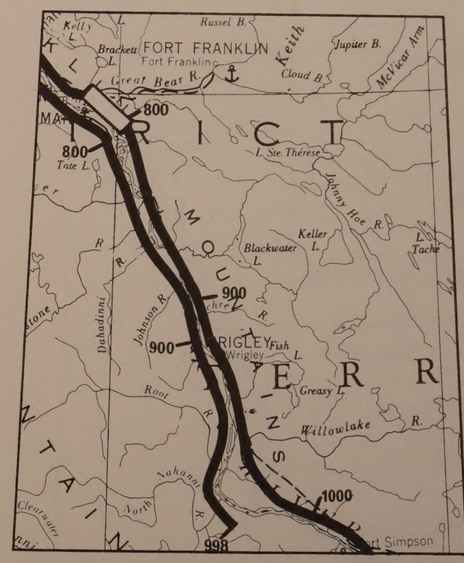


Picture: 8 Slide in decomposed shale bank.

Site: 55 $C_0$3

Picture: 9 Old slide on east bank of the Mackenzie River.

Site: 55 C_D



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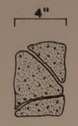
Pictures taken in early October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE
	TITLE: Photo Mosaic and Terrain Investigation MILE 776 TO MILE 803
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: R Jewell DATE: Dec/70 SITE No. 55 PLATE No. 135
	APPROVED: Gordon DATE: Dec/70 SHEET No. 29K

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

Ndn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

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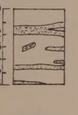

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

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Raised beach or wave-cut terrace

Drainage, emphasized to show pattern

Quaternary boundary

Extensive Muskeg or Swamp

2080 ● Test Hole Location 1969

Proposed Pipeline Route 1969

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE
56 C_T	Heavy spruce with some birch to 35'. Bog bilberry, lichen, grass and moss.	0 - 2½' PEAT, unfrozen 2½' - 30' SAND, fine, silty, frozen below 2½', ice sheen on grains, (Vc)
56 D_T	Heavy spruce to 20' in height, with some tamarack to 25'. Lichen and swamp laurel.	0 - 10' PEAT, frozen below 2', ice crystals and lenses (Vx, Vr) 10' - 20' SAND, fine silty, ice lenses (Vr)

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

RECONNAISSANCE OBSERVATION NOTES

Note — The area covered by the north half of the sheet is relatively heavily timbered, mainly spruce to 50' in height. Most lakes have well defined tree lined banks but are tending to infill with grass.

Grass islands

Grass and tree infilling on all banks

56 C_T — Test hole on a 20' to 30' high ridge as shown in Picture 1. Picture 2 shows the test site just off the seismic line and Picture 3 shows the vegetation on the continuation of the ridge.

56 D_T — Test hole located in depression adjacent to the ridge on which C_T was located. Picture 4 shows the vegetation at the test site and Picture 5 shows ice lenses in one of the samples recovered from the test hole.

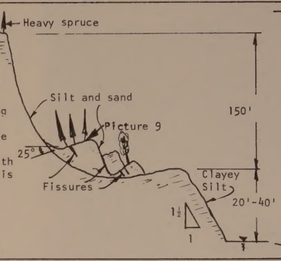
Grass-infilling lakes.

Old stream bed grass-infilled.

All lakes are grass-infilling, surrounded by spruce to 30' in height.

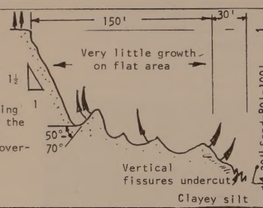
Old river bank slides in this area.

56 A_0 — A series of slides on the east bank of the Mackenzie River were investigated. Picture 6 is a high level photo showing extensive sliding on part of the bank. Pictures 7 and 8 show the slides in the 150' to 200' high bank from a lower level. Picture 9 is taken looking north from the section sketched. The river is eroding the slide material at the toe by undercutting. All slides appear to be still moving.

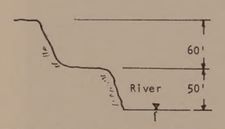


Old thermokarst area. Dense spruce surrounds lakes

56 B_0 — Pictures 10 and 11 show extensive sliding which has occurred on the east bank of the Mackenzie River. The bank as sketched appears to consist of fine silty sand overlying clayey silt.

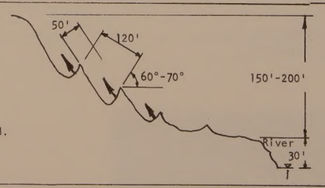


Old slide in 110' high bank adjacent to Smith Creek has profile as sketched,



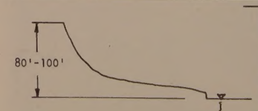
Smith River has numerous old meander channels.

Extensive slide as sketched.



40' high river banks in this vicinity are much lower and flatter than observed in the general area.

80' to 100' high banks in this vicinity have profile as sketched.

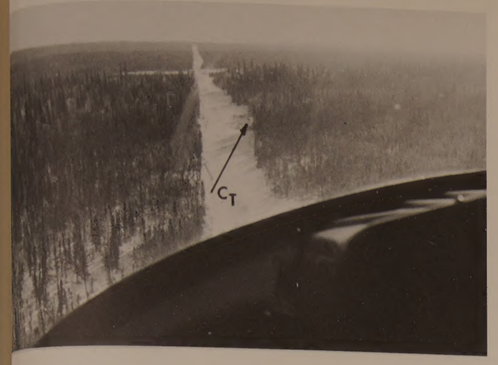


Lake has well defined banks and is surrounded by heavy spruce.

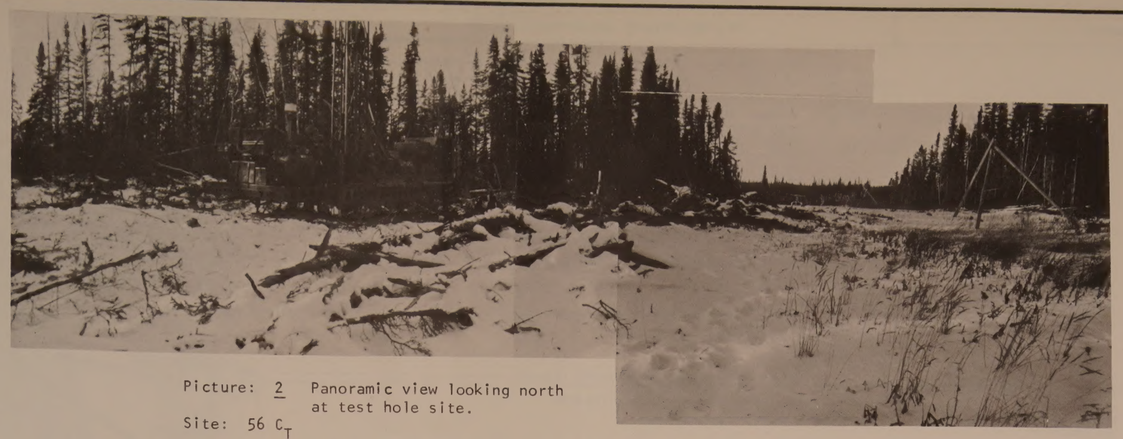
LAT. 64° 40'
LONG. 124° 50'

AVE. ALTITUDE 350'
MEAN ANNUAL AIR TEMP. 22°F

SITE NO. 56 SHEET NO. 29J
PLATE NO. 136



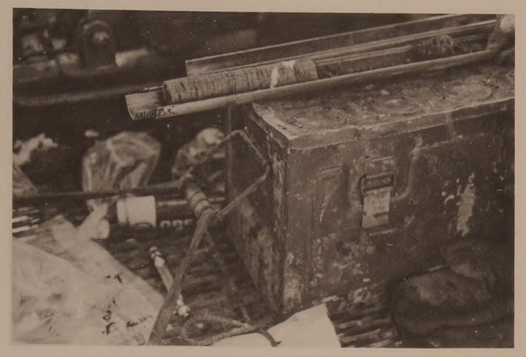
Picture: 1 Test hole location adjacent to seismic line.
Site: 56 C_T



Picture: 2 Panoramic view looking north at test hole site.
Site: 56 C_T

Picture: 3 General view of tree cover on ridge at test hole site.
Site: 56 C_T

Picture: 4 View across test site showing vegetation.
Site: 56 D_T



Picture: 5 Ice lense in sample from 10' depth in test hole.
Site: 56 D_T

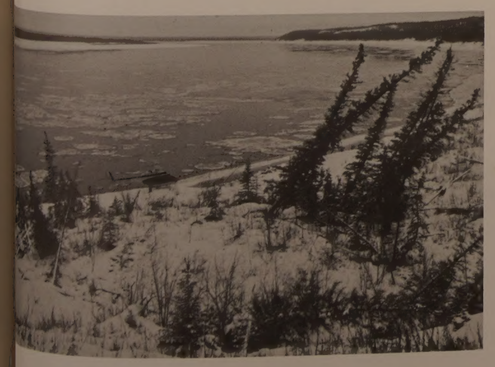
Picture: 6

View of slides on east bank of Mackenzie River from 4000'.

Site: 56 A_0

Picture: 7 View of slides on east bank of Mackenzie River.
Site: 56 A_0

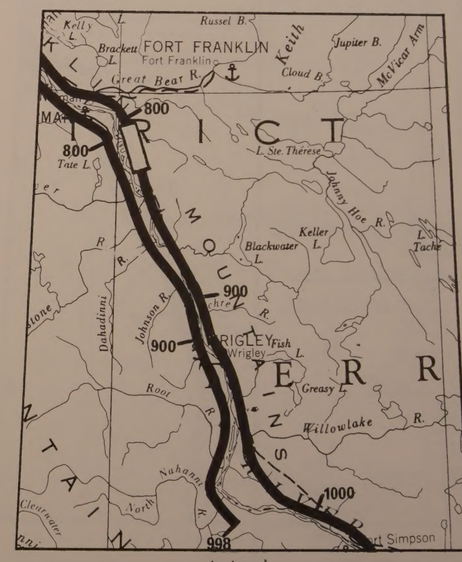
Picture: 8 Closer view of slides shown in Picture 7.
Site: 56 A_0



Picture: 9 From mid point of slide investigated, looking north.
Site: 56 A_0

Picture: 10 View of slides on east bank of Mackenzie River.
Site: 56 B_0

Picture: 11 Closer view of slides shown in Picture 10.
Site: 56 B_0



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Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 802 TO MILE 828

SUBMITTED	DATE	SITE No.	PLATE No.
R Jewell	Dec/70	56	137
APPROVED	DATE	SHEET No.	
Eurspeer	Dec/70	29J	

N.R.C. PERMAFROST CLASSIFICATION

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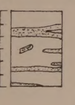

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

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Raised beach or wave-cut terrace

Drainage, emphasized to show pattern

Quaternary boundary

Extensive Muskeg or Swamp

2080 ● Test Hole Location **1969**

Proposed Pipeline Route **1969**

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
			Banks undercut by stream.
			57 D_0 Picture 1 shows unstable section of river bank on the Mackenzie River. The picture shows recent slide debris projecting into the river with older slides in the background. The profile of the bank as sketched consisted of fine sand and clayey silt.
			Undercut slide at mouth of stream
			Airstrip
			Area covered by heavy spruce to 40' in height.
57 B_T	Moderate black spruce and tamarack to 30' in height; labrador tea, bog bilberry, lichen and moss.	0 - 2½' PEAT, frozen at 21", ice crystals (Vx) 2½' - 18' GRAVEL, sandy, no visible ice (Nbn) 18'-21½' SILT, sandy,(till-like), ice lenses and coatings, (Vc, Vr)	57 B_T Test hole in dark-tone, low lying area.
57 A_T	Moderate black spruce and tamarack to 30' in height, dwarf birch; bearberry, swamp laurel, grass and moss.	0 - 2' PEAT, fibrous 2' - 11' GRAVEL, some sand, unfrozen 11' - 17' SAND, very fine, unfrozen	57 A_T Test hole in low lying sedge meadow shown in Pictures 2 and 3.
57 C_T	Moderate black spruce and tamarack to 25' in height; bog bilberry, labrador tea, lichen and moss.	0 - 2½' PEAT, unfrozen 2½' - 11' CLAY and SILT, soft, unfrozen 11' - 20' SILT, sandy,(till-like) unfrozen	57 C_T Test hole on higher, better drained ground. Picture 4 shows site vegetation.
			Depressional area is grass infilling.
			Ridge 200' in height with lakes on east side grass-infilling. Moderate spruce cover to 20' in height.
			Dense spruce in this area.
			40' to 50' high river banks in this area are relatively stable.
			Well defined lake surrounded by dense spruce, tamarack and occasional birch to 30' in height.

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
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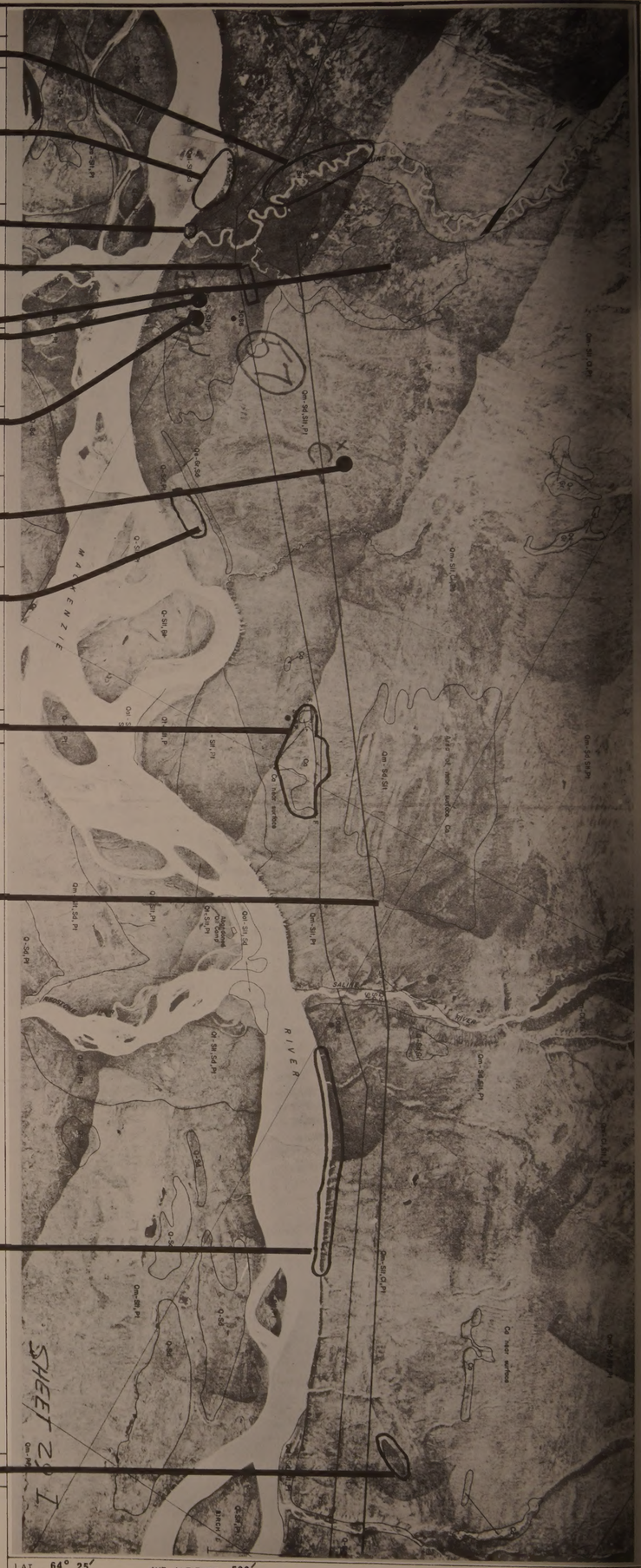

LAT. 64° 25'
LONG. 124° 40'

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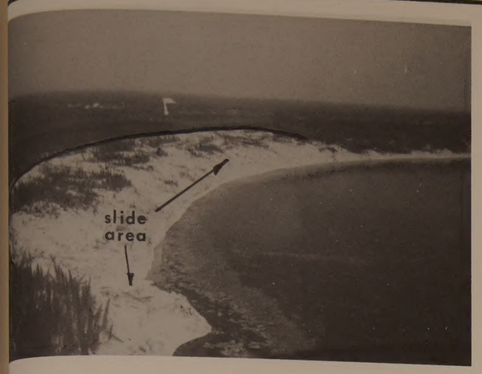
MEAN ANNUAL AIR TEMP. 22 °F

SITE NO. 57 SHEET NO. 291
PLATE NO. 138

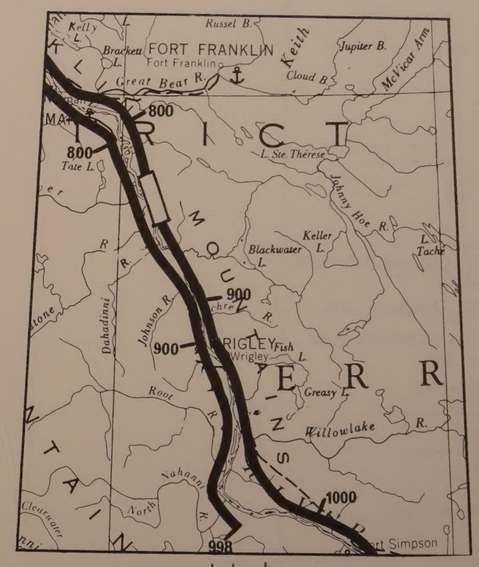


Picture: 1 View of unstable section of Mackenzie riverbank.
Site: 57 D_0

Picture: 2 View across open test site to trees.
Site: 57 A_T

Picture: 3 View across open test site to trees.
Site: 57 A_T

Picture: 4 View of trees adjacent to test hole site.
Site: 57 C_T



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Pictures taken in late October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE TITLE: Photo Mosaic and Terrain Investigation MILE 828 TO MILE 853
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: J Jewell — DATE: Dec/70 — SITE No.: 57 — PLATE No.: 139 APPROVED: Gwspeer — DATE: Dec/70 — SHEET No.: 291

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
				Muskeg and thermokarst area.
				Grass and tree infilling
	58 B_T	Sparse black spruce and tamarack to 10', dwarf birch; labrador tea, swamp laurel, grass and moss.	0 - 2½' PEAT, frozen below 2' 2½' - 13' CLAY and SILT, 10% ice, in crystals and lenses (Vx,Vr) 13' - 17' SILT, sandy, (till-like), ice crystals (Vx)	58 B_T Test hole located on the edge of a muskeg swamp and adjacent to a seismic cut line as shown in Picture 1. Picture 2 shows the site vegetation.
	58 A_T	Light black spruce to 20', tamarack to 30', and dwarf birch; labrador tea, leatherleaf, lichen and moss.	0 - 4½' PEAT, frozen below 2', ice crystals and lenses (Vx,Vr) 4½' -21½' CLAY and SILT, 5% ice, in crystals (Vx); shale fragments below 15'	58 A_T Test hole located as shown in Picture 3. Picture 4 shows the sparse vegetation across the clearing and Picture 5 shows trees adjacent to the test site on the edge of the clearing.
				Treed island
				Lake is surrounded by single row of spruce to 20' in height.
				Dense spruce in this area.
				Dense spruce on south-west side of lake. Lighter spruce and grass infill on north-west side.
				Tree and grass-infilling lake
				Gravel in riverbed
				Heavy to dense spruce to 40' in height in this area.
				Steep undercut banks on edge of river. Heavily timbered spruce on adjacent terrace.
				Lakes are grass-infilling
				Airstrip on seismic line

SEGREGATED ICE NOT VISIBLE BY EYE

- Nf — POORLY BONDED
- Nbn — WELL BONDED — NO EXCESS ICE
- Nbe — WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

- Vx — INDIVIDUAL ICE INCLUSIONS
- Vc — ICE COATINGS ON PARTICLES
- Vr — RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS
- Vs — STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

- ICE & SOIL — ICE WITH SOIL INCLUSIONS
- ICE — ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J.C. Sproule and Associates Ltd.
for
MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED
in 1969

LEGEND

MAP UNITS

QUATERNARY or HOLOCENE
- Q — Quaternary Undivided
- Qs — Slump
- Qal — Recent Alluvium
- Qt — Terrace
- Qm — Moraine
- Qe — Esker

DESCRIPTIVE ABBREVIATIONS

QUATERNARY or HOLOCENE (UNCONSOLIDATED)	PALEOZOIC – TERTIARY (BEDROCK)
Gr — Gravel	Fel — Felsenmeer (rock rubble nearly in situ)
Sd — Sand	Cgl — Conglomerate
Slt — Silt	Ss — Sandstone
Cl — Clay	Sltst — Siltstone
Pt — Peat	Sh — Shale
Ti — Till	Ca — Carbonate

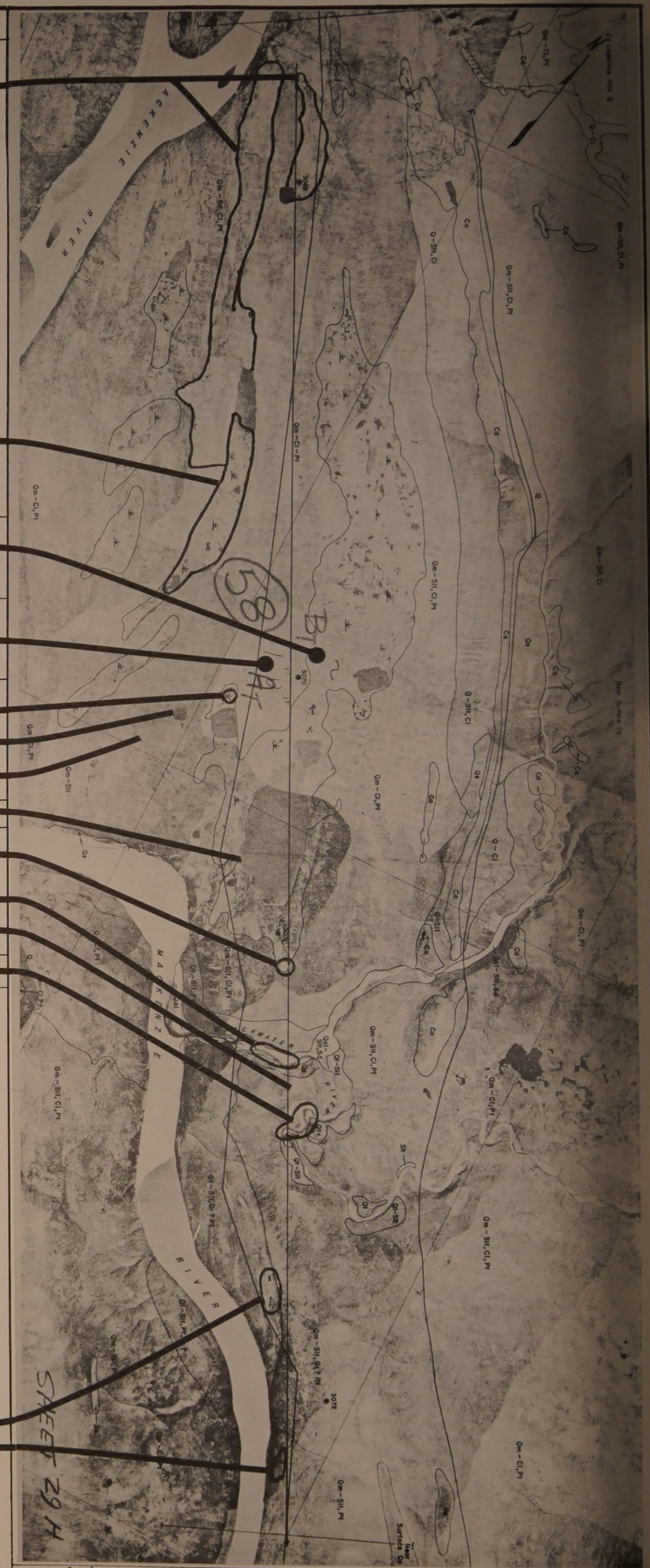
Note. Coarser or finer material listed first, depending upon which is believed to be more abundant.

SYMBOLS

- Fault, F — major, f — minor; U — upthrown, D — downthrown side; arrows indicate direction of apparent horizontal movement — Defined / Approximate / Assumed
- Raised beach or wave-cut terrace
- Drainage, emphasized to show pattern
- Quaternary boundary
- Extensive Muskeg or Swamp
- 2050 ● Test Hole Location 1969
- Proposed Pipeline Route 1969

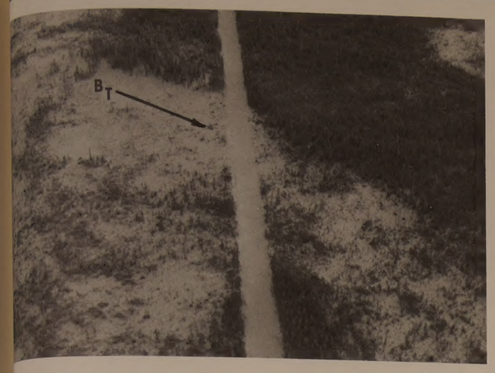
NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "



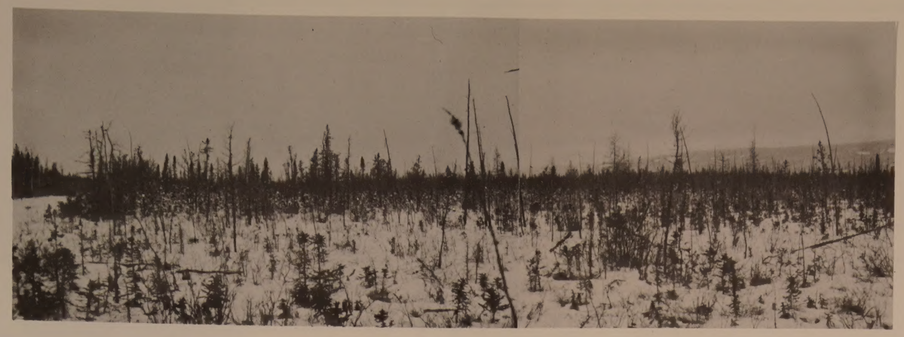
LAT. 64° 00'
LONG 124° 10'
AVE. ALTITUDE 550'
MEAN ANNUAL AIR TEMP. 22°F

SITE NO. 58 SHEET NO. 29H
PLATE NO. 140



Picture: 1 View looking south at test site.

Site: 58 B_T



Picture; 2 View looking north across test hole site.

Site: 58 B_T

Picture: 3 View looking north at test hole site.

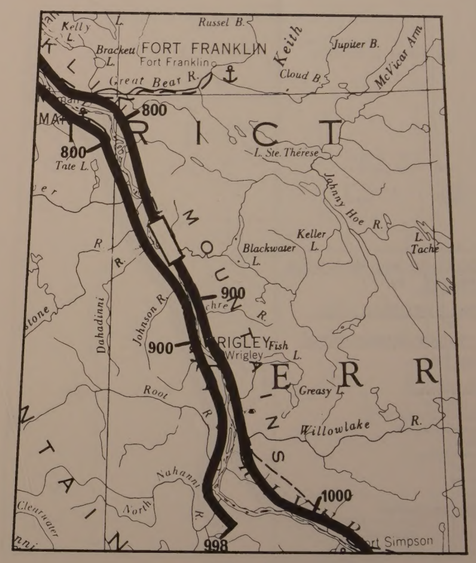
Site: 58 A_T

Picture: 4 Looking east from test hole site.

Site: 58 A_T

Picture: 5 Looking west across site to adjacent trees.

Site: 58 A_T



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Pictures taken late October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE TITLE: Photo Mosaic and Terrain Investigation MILE 853 TO MILE 878
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: L Jewell, DATE: Dec/70, SITE No. 58, PLATE No. 141 APPROVED: [illegible], DATE: Dec/70, SHEET No. 29H

N.R.C. PERMAFROST CLASSIFICATION

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Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

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Vx INDIVIDUAL ICE INCLUSIONS

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Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

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ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J.C. Sproule and Associates Ltd.
for
MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED
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NOTE: Tree Population

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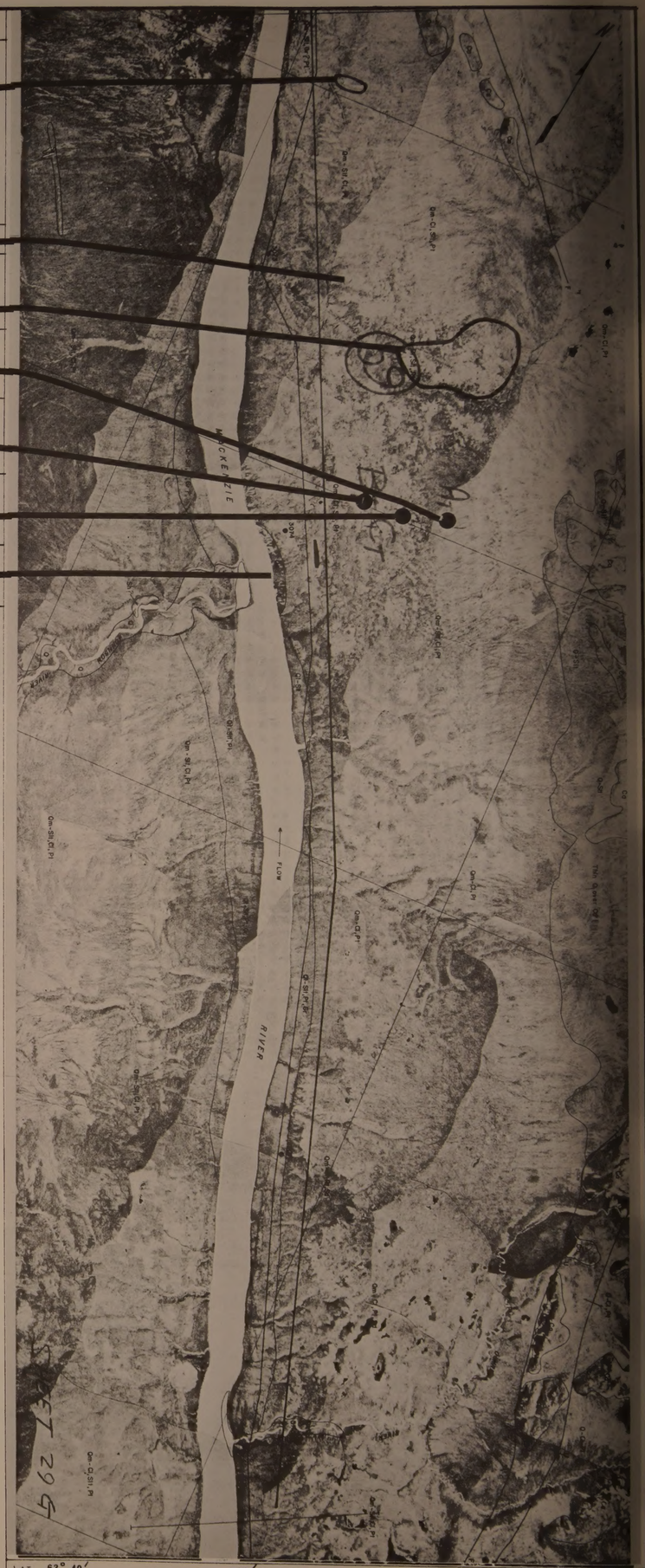
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
			Esker-like ridge
			Speckled pattern on mosaic appears to be due to variations in density of tree cover.
			Old thermokarst area is tree and grass infilling.
59 A_T	Leatherleaf, grass and moss adjacent to the test site are moderate black spruce and tamarack to 20' in height, dwarf b birch and pine.	0 - 1½' PEAT, unfrozen 1½' - 10' CLAY, silty, frozen below 4½', few ice crystals (Vx) 10' - 22' CLAY and SILT, few ice crystals (Vx)	59 A_T Test hole located in small clearing as shown in Picture 1. Note the burned out area south of the site. Picture 2 shows tree cover adjacent to the site.
59 B_T	Dead-fall of tamarack and birch on the site with labrador tea and moss. In the general area there are sparse black and white spruce to 30' in height, dwarf birch and willows.	0 - ½' ORGANIC ½' -21½' SILT, clayey. (till-like) frozen below 3', ice crystals and lenses (Vx, Vr)	59 B_T Test hole located as shown in Picture 3. Picture 4 shows vegetation at test site.
59 C_T	Moderate black spruce (few to 40' in height), pines and tamarack surround the circular shaped bog. Willows to 4', stunted spruce and dwarf birch, labrador tea, swamp laurel, grass and moss.	0 - 3½' PEAT, frozen below 2', ice crystals and lenses (Vx, Vr) 3½' - 22' SILT, organic, few ice crystals (Vx) to 10' depth then ice crystals and lenses (Vx, Vr)	59 C_T Test hole located in a swampy area as shown in Picture 5. Picture 6 shows a small frozen pond adjacent to the test hole.
			59 D_0 Picture 7 shows exposed thaw banks on the Mackenzie River. The bank height is 100' with boulders at the toe of the slope, samples of which were identified as granite, diorite, dolomite and mica.


MACKENZIE
RIVER
FLOW
Qm-SR(M)
Qm-SR(P)
Qm-SR(M)
Qm-SR(P)
Qm-SR(M)
Qm-SR(P)

Picture: 1 Looking north west at test hole site

Site: 59 A_T

Picture: 2 View across site to north west.

Site: 59 A_T

Picture: 3 Looking south west at test hole site.

Site: 59 B_T

Picture: 4 View looking north east across test hole site.

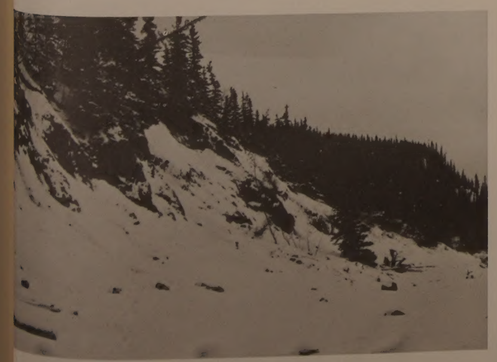
Site: 59 B_T

Picture: 5 Looking south east at test hole site

Site: 59 C_T

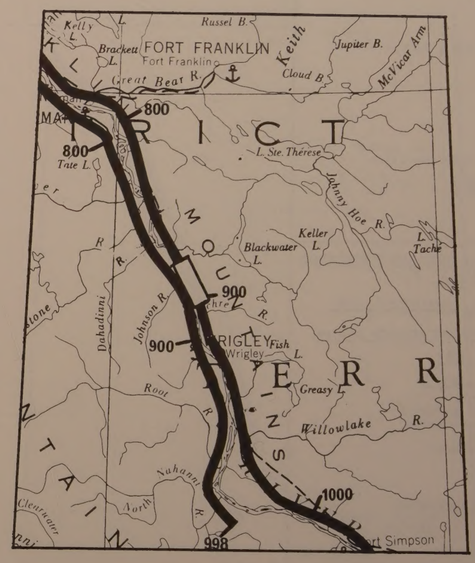
Picture: 6 Looking north across partially infilled pond adjacent to site

Site: 59 C_T



Picture: 7 Thaw bank on east side of Mackenzie River. Note boulders at base of bank.

Site: 59 D_0



Pictures taken in late October, 1970

Ripley, Klohn & Leonoff Alberta Ltd.

CONSULTING ENGINEERS

CANADA

VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation

MILE 878 TO MILE 903

SUBMITTED	DATE	SITE No.	PLATE No.
L Jewell	Dec/70	59	143
APPROVED	DATE	SHEET No.	
Lundquist	Dec/70	29G	

N.R.C. PERMAFROST CLASSIFICATION

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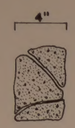

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ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL – ▨ ICE – □

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Light	15' to 25' "
Sparse	> 25' "

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
60 A_T	Sparse black spruce to 10' in height, burned out tamarack, black spruce and dwarf birch. Clearing surrounded by dense black spruce and tamarack to 40' in height. Labrador tea, grass and moss.	0 - 5' PEAT, unfrozen 5' - 22' SILT, clayey, frozen below 5', few ice crystals (Vx)	60 A_T Test hole located in a circular clearing in better-drained old burn area shown in Picture 1. Probing in the trees adjacent to the site indicated frost depth at 18".
60 B_T	Sparse dwarf birch, black and white spruce and a few pine. Tall, dense black spruce and tamarack to the southwest. Bearberry, labrador tea, swamp laurel, lichen and moss.	0 - 10' PEAT, frozen below 10', ice crystals (Vx) 10' - 22' SILT and CLAY, organic, ice lenses and crystals (Vr, Vx)	60 B_T Test hole located on high wooded peat plateau in palsa bog as indicated in Picture 2. The lake level adjacent to the site is 20' lower than the test site. Picture 3 shows lake from top of plateau and Picture 4 shows ice lenses in a sample recovered from the test hole.
60 C_T	Light black spruce, birch and tamarack to 30'; bearberry, swamp laurel, and lichen.	0 - 9½' PEAT, frozen below 2', few ice crystals (Vx) 9½' - 22' SILT and SAND, clayey, ice crystals and lenses (Vr, Vx)	60 C_T Test hole located in a low area adjacent to a peat mound in a palsa bog as shown in Picture 5. Picture 6 shows vegetation adjacent to the test site which is on an old burn, and Picture 7 shows ice lenses in a sample recovered from the test hole.

Esker-like ridges
Thermokarst area. Most lakes are grass-infilling.
Well-defined shoreline
200' high ridge adjacent to test site.
Old Wrigley townsite, now abandoned
Sedimentary rock (sandstone or limestone) exposed on riverbank.
Present Wrigley settlement and airstrip.

LAT. 63° 20'
LONG 123° 40'

AVE. ALTITUDE 600'
MEAN ANNUAL AIR TEMP. 23°F

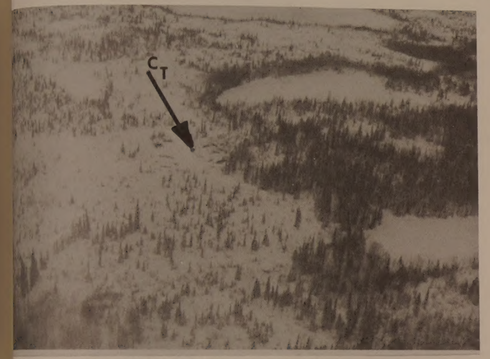
SITE NO. 60 SHEET NO. 29 F
PLATE NO. 144

Picture: 1 Looking north east at test hole site.
Site: 60 A_T

Picture: 2 Looking south at test hole site. Edge of 200' high ridge visible to right.
Site: 60 B_T

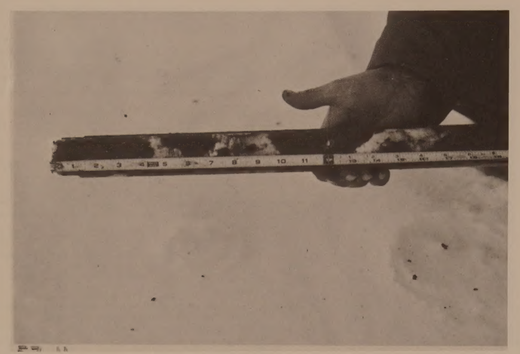
Picture: 3 Looking west toward small lake 20' below level of test site.
Site: 60 B_T

Picture: 4 Sample No. 4 at 10' depth from test hole.
Site: 60 B_T

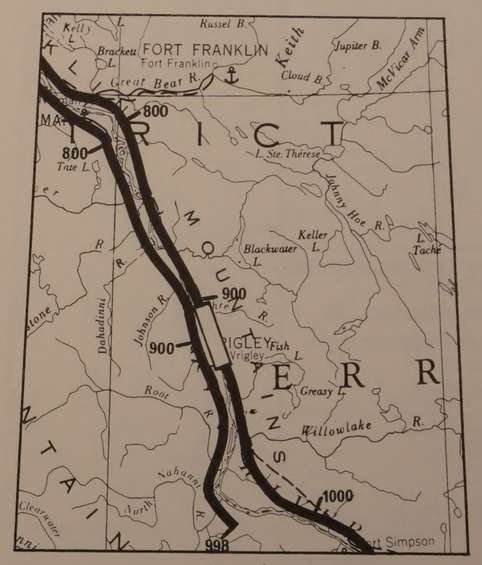


Picture: 5 Looking west at test hole site.
Site: 60 C_T

Picture: 6 Looking north west from test hole site toward drainage channel
Site: 60 C_T



Picture: 7 Sample No. 4 at 10' depth from test hole.
Site: 60 C_T



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Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE				
	TITLE: Photo Mosaic and Terrain Investigation MILE 903 TO MILE 929				
	SUBMITTED: L Jewell	DATE: Dec/70	SITE No. 60	PLATE No. 145	
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	APPROVED: Eudgeon	DATE: Dec/70	SHEET No. 29F		

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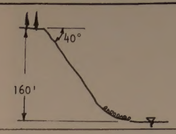
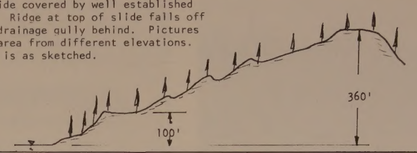
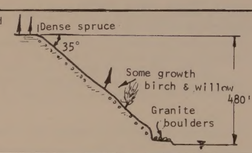
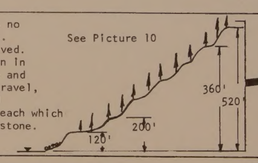
TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
			61 E_0 Steep riverbank shown in Picture 1 was composed entirely of till-like, silty gravel as shown in Picture 2. Cobbles on beach as in Picture 3 were identified as granite, gabbro and quartzite. NOTE: The bank at E_0 is steeper but not as high as that at A_0. 
			Well-defined lake edges in TK area.
			Grass-infilling lake.
			Old thermokarst area with moderate spruce and tamarack to 20' in height. Lakes are generally grass-infilling on all banks.
			61 C_0 Old stable slide covered by well established white spruce. Ridge at top of slide falls off sharply into drainage gully behind. Pictures 4 and 5 show area from different elevations. Slide profile is as sketched. 
			61 F_0 A core shaped depression 80' in diameter and 15' deep was investigated Beneath the heavy snow cover shown in Picture 6, a thin layer of silt was found over sand and gravel in excess of 3' thick. Heavy white spruce to 60' in height grew within and adjacent to the depression. Frost was encountered at 3' within the cone.
61 D_T	Heavy white and black spruce to 50' in height, with a few poplar and birch to 40' in height; willows and dwarf birch. Bearberry, lichen and moss.	0 - 4½' PEAT, unfrozen 4½' - 10' SAND and GRAVEL, well graded, unfrozen	61 D_T Test hole located on edge of 500' high river bank, shown in Picture 7. Picture 8 looks down to the river and Picture 9 shows heavy timber across the test site from edge of bank.
			61 A_0 Steep riverbank as sketched was composed of till-like silty gravel. Samples of the gravel were identified as granite and ortho-sandstone. 
			Thermokarst area with palsa mounds to 10' in height surrounding most lakes.
			61 B_0 Old slide area shown in Picture 10. There was no evidence of leaning trees or fresh slide scars. Typical slump topography as sketched was observed. Northern end of slide, and slumping can be seen in Picture 11. Tree growth is dense white spruce and birch. Picture 12 shows till-like, silt and gravel, exposed in the lower section of the bank, and Picture 13 shows cobbles and boulders on the beach which were identified as granite, quartzite and limestone. See Picture 10 
			Picture 14 shows typical terrain.
			Mineralized springs on small island.
			Esker-like ridges
			Undercut bank 60' in height.
			Airstrip
			Creek bed is grass-infilling

LAT. 63° 05'
LONG 123° 15'
AVE. ALTITUDE 600'
MEAN ANNUAL AIR TEMP. 23° F

SITE NO. 61 SHEET NO. 29E
PLATE NO. 146

Picture: 1 View of right bank of Mackenzie River.
Site: 61 E_0

Picture: 2
Till-like, silty gravel at lower section of steep bank.
Site: 61 E_0

Picture: 3 Cobbles on beach at toe of bank.
Site: 61 E_0

Picture: 4 View of old slide from 1500' above ground.
Site: 61 C_0

Picture: 5 View of old slide from 500' above ground.
Site: 61 C_0

Picture: 6
Deep snow in conical shaped depression.
Site: 61 F_0

Picture: 7 Test hole site on edge of 500' high east bank of Mackenzie River.
Site: 61 D_T

Picture: 8 View looking down the slope of the river bank.
Site: 61 D_T

Picture: 9 Looking across test hole site to trees beyond.
Site: 61 D_T

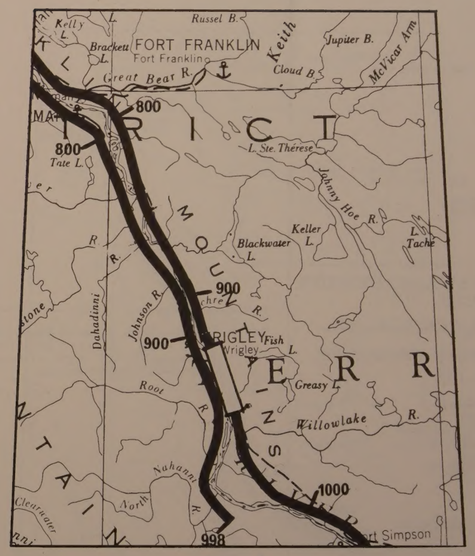
Picture: 10 Large slide on east bank of Mackenzie River.
Site: 61 B_0

Picture: 11 Northern end of slide.
Site: 61 B_0

Picture: 12 Till-like, silt and gravel in lower part of bank.
Site: 61 B_0

Picture: 13 Cobbles and boulders on beach.
Site: 61 B_0

Picture: 14 General view looking south west toward Camsell Range.
Site: 61



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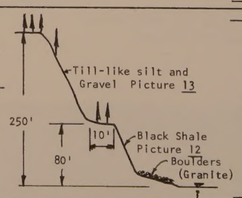
Pictures taken in late October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE		
	TITLE: Photo Mosaic and Terrain Investigation MILE 922 TO MILE 953		
	SUBMITTED: R Jewell	DATE: Dec/70	SITE No.: 61
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	APPROVED: [illegible]	DATE: Dec/70	SHEET No.: 29E
			PLATE No.: 147

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
SEGREGATED ICE NOT VISIBLE BY EYE. Nf — POORLY BONDED Nbn — WELL BONDED – NO EXCESS ICE Nbe — WELL BONDED – EXCESS ICE				Tree cover is generally heavy spruce to 40' in height. Lake is well-defined with grass island.
VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK. Vx — INDIVIDUAL ICE INCLUSIONS Vc — ICE COATINGS ON PARTICLES Vr — RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS Vs — STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS				Sink hole adjacent to butte. Pictures 1 and 2 and 3. Deep erosion valley. Sedimentary bedrock Lake was not frozen on November 3, 1970. Extensive esker-like ridge shown in Picture 5.
VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK ICE & SOIL — ICE WITH SOIL INCLUSIONS ICE — ICE WITHOUT SOIL INCLUSIONS LEGEND: SOIL – ICE –				Glacial fluting shown in Picture 4. Grass infilling at each end of elongate lakes in this area. Picture 6 shows area to south east from 5000' above sea level.
	62 B_T	Heavy black and white spruce to 10' in height. Spruce to 50', birch and tamarack to 30' south of the site. Bearberry, lichen and moss.	0 - ½' ORGANIC ½' - 22' CLAY and SILT, sandy, (till-like), frozen below 2', few ice crystals (Vx)	62 B_T Test hole located on crest of drumlinoidal ridge shown in Pictures 7 and 8. Picture 9 shows the tree cover on the site.
	62 A_0	Riverbank exposure checked for soil type. Original location of A_0 shown on mosaic was not accessible. Picture 10 looks north from original location to location checked on Willow Lake River. Picture 11 shows bank as sketched and Picture 12 and 13 respectively show weathered shale, and till-like silt and gravel in bank. The beach shown in Picture 11 was covered with boulders similar to those in Picture 14.		62 A_0
				Creek in deeply eroded valley Picture 15 shows high ridge. Heavily treed ridges, oriented NW-SE.

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by–

J.C. Sproule and Associates Ltd.
for
MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED
in 1969

LEGEND

MAP UNITS

QUATERNARY or HOLOCENE
- Q — Quaternary Undivided
- Qs — Slump
- Qal — Recent Alluvium
- Qt — Terrace
- Qm — Moraine
- Qe — Esker

DESCRIPTIVE ABBREVIATIONS

QUATERNARY or HOLOCENE (UNCONSOLIDATED)	PALEOZOIC – TERTIARY (BEDROCK)
Gr — Gravel	Fel — Felsenmeer (rock rubble nearly in situ)
Sd — Sand	Cgl — Conglomerate
Slt — Silt	Ss — Sandstone
Cl — Clay	Sltst — Siltstone
Pt — Peat	Sh — Shale
Ti — Till	Ca — Carbonate

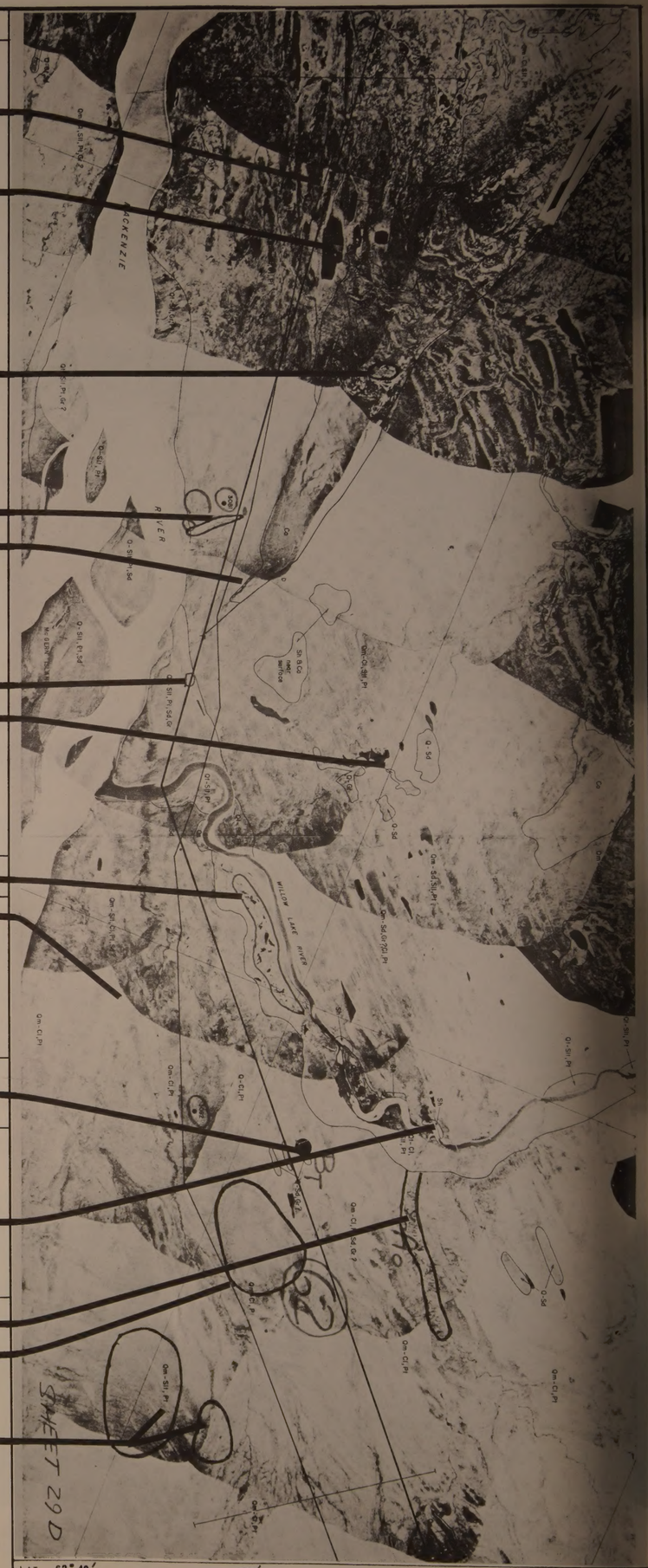
Note: Coarser or finer material listed first, depending upon which is believed to be more abundant.

SYMBOLS

- Fault, F – major, f – minor; U – upthrown, D – downthrown side; arrows indicate direction of apparent horizontal movement — Defined / Approximate / Assumed
- Raised beach or wave-cut terrace
- Drainage, emphasized to show pattern
- Quaternary boundary
- Extensive Muskeg or Swamp
- 2080 ● Test Hole Location 1969
- Proposed Pipeline Route 1969

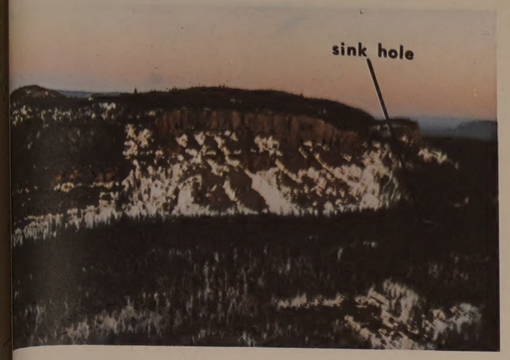
NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "



LAT. 62° 40′ LONG. 123° 00′ AVE. ALTITUDE 500′ MEAN ANNUAL AIR TEMP. 24° F

SITE NO. 62 SHEET NO. 29D PLATE NO. 148



Picture: 1 Showing location of sinkhole adjacent to butte.
Site: 62 D_0

Picture: 2 Sinkhole adjacent to butte
Site: 62 D_0

Picture: 3 View of rock strata from helicopter flying inside sink hole
Site: 62 D_0

Picture: 4 View looking north along fluting adjacent to Willow Lake River.
Site: 62

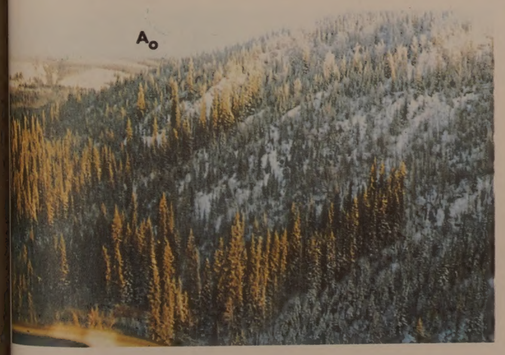
Picture: 5 Looking east over extensive esker-like ridge.
Site: 62

Picture: 6 General view looking south east from 5000'
Site: 62

Picture: 7 View of test hole site on drumlinoidal ridge.
Site: 62 B_T

Picture: 8 Closer view of test hole site.
Site: 62 B_T

Picture: 9 View across test hole site.
Site: 62 B_T



Picture: 10 View looking north along creek toward exposed Willow Lake River bank.
Site: 62 A_0

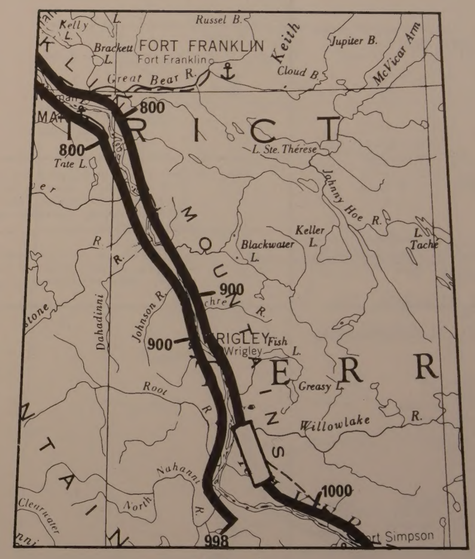
Picture: 11 Willow Lake River bank.
Site: 62 A_0

Picture: 12 Shale bedrock exposed in bank.
Site: 62 A_0

Picture: 13 Till-like silt and gravel in bank.
Site: 62 A_0

Picture: 14 Typical boulders on beach.
Site: 62 A_0

Picture: 15 Looking north west at ridge.
Site: 62 A_0



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Pictures taken in late October, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE
	TITLE: Photo Mosaic and Terrain Investigation MILE 955 TO MILE 980
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: R. Jewell DATE: Dec/70 SITE No.: 62 PLATE No.: 149
	APPROVED: DATE: SHEET No.: 29 D

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL- ▩ ICE- □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J.C. Sproule and Associates Ltd.
for
MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED
in 1969

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Pt — Peat	Siltst — Siltstone
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	Co — Carbonate

Note. Coarser or finer material listed first, depending upon which is believed to be more abundant.

SYMBOLS

F—U—f Fault, F—major, f—minor, U—upthrown, D—downthrown side, arrows indicate direction of apparent horizontal movement — Defined / Approximate / Assumed

Raised beach or wave-cut terrace

Drainage, emphasized to show pattern

Quaternary boundary

Extensive Muskeg or Swamp

2090 Test Hole Location 1969

Proposed Pipeline Route 1969

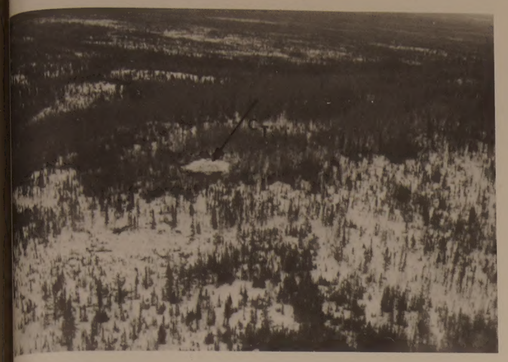
NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
			Moderate spruce in old burn area
			Large esker-like ridge
			Extensive thermokarst area
			Active thaw lakes with linear shorelines.
			40' high knoll assumed to be continuation of esker-like ridge.
63 C_T	Moderate birch to 20' in height with some black spruce and dwarf birch. Bearberry, lichen and moss. North-west of site, and lower in elevation are moderate pines.	0 - 9½' CLAY and SILT, unfrozen 9½' - 22' SAND, GRAVEL and SILT. (till-like), frozen below 20'.	63 C_T Test hole located on an esker-like ridge shown in Picture 1. Picture 2 shows surface of ridge which at this point is approximately 30' above general terrain level.
			Small esker-like ridges shown in Picture 3, are oriented normal to the drainage pattern down the sheetwash slope.
63 A_T	Dense black spruce and a few birch to 25' in height, tamarack to 50' in height. Small poplar, dwarf birch and willow. Labrador tea, grass and moss.	0 - 2' ORGANIC 2' - 22' SAND, GRAVEL, and CLAY. (till-like) frozen below 2', ice crystals (Vx)	63 A_T Test hole on upper sheetwash slope. Picture 4 from the air and Picture 5 from the ground show site and vegetation.
63 B_T	Dense willows to 20' in height, with a few poplar, birch and black spruce. Bearberry and moss.	0 - 2' ORGANIC 2' - 22' SILT, and CLAY, sandy. (till-like), frozen below 5', ice crystals (Vx)	63 B_T Test hole site shown in Pictures 6 and 7 is down the sheetwash slope from 63 A_T and is approximately 300' lower in elevation.
			Airstrip alongside telephone line
			Heavy spruce to 40' in height on edge of distinct lakeshore.
			Light to medium spruce, some pine and tamarack to 30' in height in this area. Higher and more dense growth on creek banks.
			Small grass-infilling lake at edge of scarp.
			Generally flat plateau with higher trees lining drainage channels
			Several small esker-like ridges in this area.

LAT. 62° 20′ LONG 122° 30′ AVE. ALTITUDE 1300′ MEAN ANNUAL AIR TEMP. 25° F

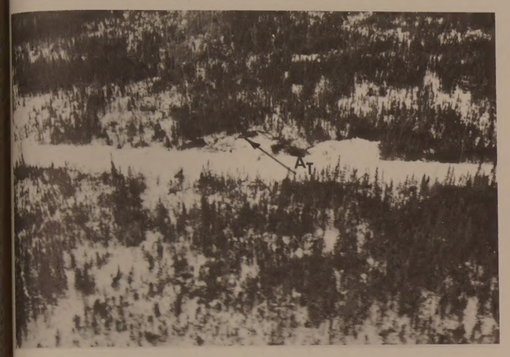
SITE NO. 63 SHEET NO. 29C PLATE NO. 150



Picture: 1 View of test hole site on esker-like ridge.
Site: 63 C_T

Picture: 2 View across test hole site.
Site: 63 C_T

Picture: 3 Esker-like ridges oriented normal to drainage path.
Site: 63

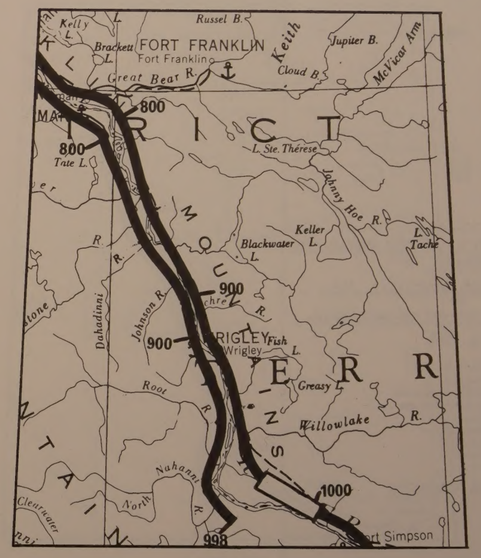


Picture: 4 View of test hole site alongside seismic cut line.
Site: 63 A_T

Picture: 5 Looking from cut line to test hole site.
Site: 63 A_T

Picture: 6 View of test hole site adjacent to seismic cut line.
Site: 63 B_T

Picture: 7 View across test hole site in willows.
Site: 63 B_T



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Pictures taken in early November, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 978 TO MILE 1003

SUBMITTED	DATE	SITE No.	PLATE No.
L Jewell	Dec/70	63	151
APPROVED	DATE	SHEET No.	
	Dec/70	29C	

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL – ▒ ICE – □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by–

J.C. Sproule and Associates Ltd.
for
MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED
in 1969

LEGEND

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- Sd — Sand
- Slt — Silt
- Cl — Clay
- Pt — Peat
- Ti — Till

PALEOZOIC – TERTIARY (BEDROCK)
- Fel — Felsenmeer (rock rubble nearly in situ)
- Cgl — Conglomerate
- Ss — Sandstone
- Sltst — Siltstone
- Sh — Shale
- Co — Carbonate

Note. Coarser or finer material listed first, depending upon which is believed to be more abundant.

SYMBOLS

Fault, F – major, f – minor; U – upthrown, D – downthrown side, arrows indicate direction of apparent horizontal movement — Defined / Approximate / Assumed

Raised beach or wave-cut terrace

Drainage, emphasized to show pattern

Quaternary boundary

Extensive Muskeg or Swamp

2080 ● Test Hole Location 1969

Proposed Pipeline Route 1969

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE
64 A_T	Sparse pines to 15' in height, spruce to 3' in height and an occasional birch; bearberry, labrador tea and lichen.	0 - 15' PEAT, frozen below 2', ice crystals (Vx) 15' - 30' SILT, sandy, ice crystals (Vx) 30' - 32' SAND and GRAVEL, silty, (till-like)
64 B_T	Heavy poplars, pines and black spruce to 40' in height, with some small willows; bearberry.	0 - 3" ORGANIC 3" - 22' SAND and SILT.(till-like), unfrozen.
64 C_T	Sparse spruce and birch to 15' in height. Bearberry, labrador tea, lichen and moss. Dense willow to 20' in height just east of the site.	0 - 2' ORGANIC 2' - 5' SILT, clayey, frozen below 2', ice crystals (Vx) 5' - 22' SAND and GRAVEL, silty. (till-like), no visible ice, (Nbn)

NOTE: Tree Population

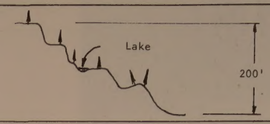
Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

RECONNAISSANCE OBSERVATION NOTES

Old infilled thermokarst area shown to right of Picture 1.

Escarpment of Ebbutt Hills shown in Picture 2 has recent slide scars

Large recent slide has profile as sketched.



64 A_T Test hole located adjacent to infilling thaw pond in thermokarst terrain as shown in Picture 3. Picture 4 shows peat mounds adjacent to the frozen thaw pond. Drill was located on a peat mound 15' east of the thaw pond. Picture 5 shows a close-up view of the surface vegetation.

64 B_T Test hole located on crest of large kame. Picture 6 shows the profile of the kame at the test hole location as well as the site vegetation.

64 C_T Test hole located on old burn adjacent to heavily timbered drainage path as shown in Picture 7. Picture 8 shows the site vegetation.

Drainage area lightly timbered

Medium spruce some pine to 20' in height with areas of tamarack in foothills as in Picture 9. Heavier tree growth appears to coincide with drainage paths.

Dense spruce and pine line banks of creek to 30' in height.

Grass infill with sparse black spruce to 10' in height in thermokarst area.

Heavy spruce to 30' in height covers area; increasing to 45' at Trail River.

No apparent sources of sand or gravel in river.

Old grass infilled thermokarst area with sparse spruce to 20' in height.

Airstrip adjacent to telephone line.

Extensive thermokarst terrain

Grass-infilling around perimeter of lake.

Thick pine and spruce growth.

Grass-infilling drainage channel.

64
Qm-Sli-Cl,Pt
Qm-Sli-Sd,Pt

Picture: 1 Looking south at infilled thermokarst area.
Site: 64

Picture: 2 Looking north at escarpment of the Ebbutt Hills.
Site: 64

Picture: 3 View of test hole site in area of thermokarst thaw ponds.
Site: 64 A_T

Picture: 4 Bank of thaw pond and test hole site vegetation.
Site: 64 A_T

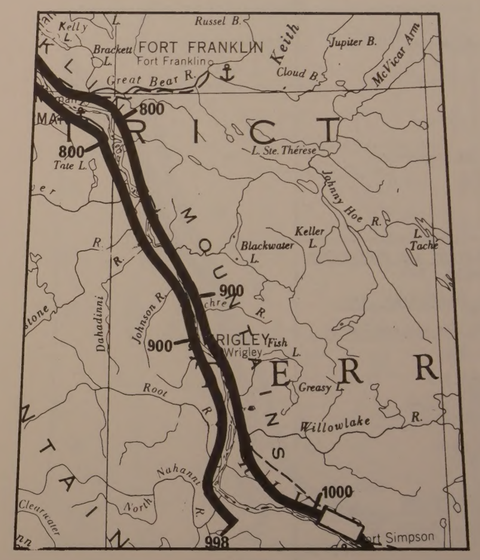
Picture: 5 Close-up of vegetation at test hole site.
Site: 64 A_T

Picture: 6 Panorama looking across test hole site.
Site: 64 B_T

Picture: 7 Location of test hole.
Site: 64 C_T

Picture: 8 Panorama looking east across test hole site to Ebbutt Hills
Site: 64 C_T

Picture: 9 View looking north east toward Ebbutt Hills.
Site: 64



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Pictures taken in early November, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE
	TITLE: Photo Mosaic and Terrain Investigation MILE 1003 TO MILE 1026
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: L Jewell DATE: Dec/70 SITE No.: 64 PLATE No.: 153
	APPROVED: Ewbank DATE: Dec/70 SHEET No.: 29B

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

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Nbn WELL BONDED – NO EXCESS ICE

Nbe WELL BONDED – EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

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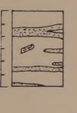
VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL – ICE –

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by–

J.C. Sproule and Associates Ltd.
for
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Sd — Sand	Cgl — Conglomerate
Slt — Silt	Ss — Sandstone
Cl — Clay	Slst — Siltstone
Pt — Peat	Sh — Shale
Ti — Till	Ca — Carbonate

Note. Coarser or finer material listed first, depending upon which is believed to be more abundant.

SYMBOLS

F — U / D — f — Fault, F – major, f – minor; U – upthrown, D – downthrown side, arrows indicate direction of apparent horizontal movement (Defined / Approximate / Assumed)

Raised beach or wave-cut terrace

Drainage, emphasized to show pattern

Quaternary boundary

Extensive Muskeg or Swamp

2080 ● Test Hole Location 1969

Proposed Pipeline Route 1969

65 B_0 Pictures 1 and 2 show a large slide in silty material. Picture 3 taken further west shows extensive instability along 8 miles of the left bank of the Mackenzie River ending in the slide, shown in Picture 1. The recent slide in the foreground of Picture 3 has occurred in silty clay.

65 A_0 Observations on 12 mile section of river bank opposite Fort Simpson. Bank height varies from 30' to 110' along the section. Various bank sections are shown in Pictures 4, 5, 6 and 7. The panoramic view in Picture 8 is of 80' high bank in Picture 5. The soil profile under the organic surface layer consists of boulder rich silt till overlying a silty gravel till. A sloping interface between the silty gravel till and an underlying sandy gravel till can be seen to the right of the picture. This interface is shown in more detail in Picture 9.

The entire 12 mile section of beach was covered by sand, gravel and boulders. Picture 11 shows a section of river bank just upstream of the junction with the Liard River on which the boulders pave the shoreline.

A number of minor block slides were observed along the section, extending no more than 100' back from the top of the bank. Pictures 12 and 13 show typical views of these slides.

65 $A_0 1$ Picture 12 shows minor slide in 40' high river bank.

65 $A_0 2$ 80' high bank shown in Picture 5 is shown in more detail in Pictures 8 and 9. A description of the soil profile is given in 65 A_0 above.

65 $A_0 3$ Picture 4 shows 40' high riverbank sloping uniformly back from the river.

65 $A_0 4$ Picture 13 shows old slide in 40' high bank.

65 $A_0 5$ Picture 6 shows 110' high riverbank.

65 $A_0 6$ Picture 7 shows 80' high riverbank sloping from the river.

65 $A_0 7$ Picture 10 shows heavy boulder cover on beach slope.

65 $A_0 8$ Minor slides in these locations.

65 $A_0 9$ Picture 11 shows large boulders paving shore.

MACKENZIE
RIVER
Ao
A1
A2
A3
A4
A5
A6
A7
A8
A9
B0
Qm-Sh,Si,Pt
Qm-Sh,Ti,Pt
Qm-Sh,Si,Pt
Qm-Sh,Ti,Pt
Qm-Cl,Ti,Pt
Qm-Sh,Ti,Pt
Qm-Sh,Ti,Pt
Qm-Sh

Picture: 1

Looking SE at slide in silt on left bank of MacKenzie, 12 miles NW of FT. Simpson.

Site: 65 B_0

Picture: 2 Closer view of slide in Picture 1.

Site: 65 B_0

Picture: 3 Looking SE at slides occurring along 8 miles of left bank of Mackenzie River. Note slide in foreground.

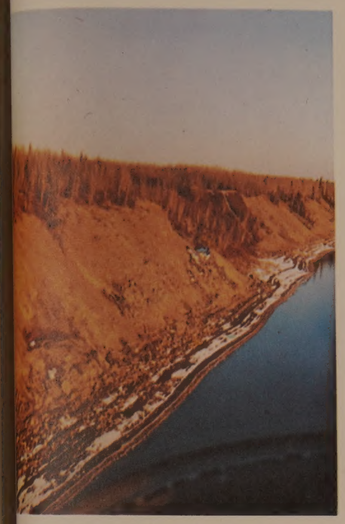
Site: 65B_0

Picture: 4 Looking SE at 40' high right bank of Mackenzie River.

Site $A_0 3$

Picture: 5 Looking SE at 80' high right bank of MacKenzie River.

Site: 65 $A_0 2$



Picture: 6

Looking SE at 110' high right bank of MacKenzie River opposite Ft. Simpson.

Site: 65 $A_0 5$

Picture: 7 Looking SE at 80' high right bank of Mackenzie River

Site: 65 $A_0 6$

Picture: 8 Close-up panoramic view of exposed riverbank shown in Picture 5.

Site: 65 $A_0 2$

Picture: 9 Close-up of the sloping interface between sandy-gravel till and silty-gravel till shown in Picture 8.

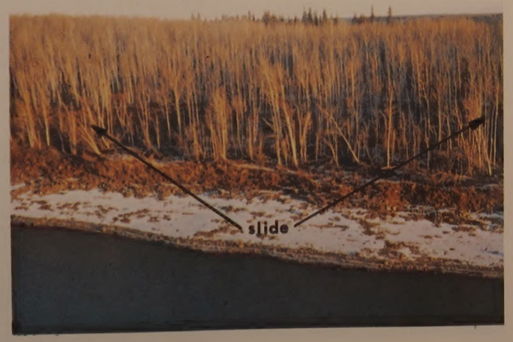
Site: 65 $A_0 2$

Picture: 10 Looking SE at heavy boulder deposits on riverbank.

Site: 65 $A_0 7$

Picture: 11 Large boulders on right bank of Mackenzie River smoothed down by ice action.

Site: 65 $A_0 9$

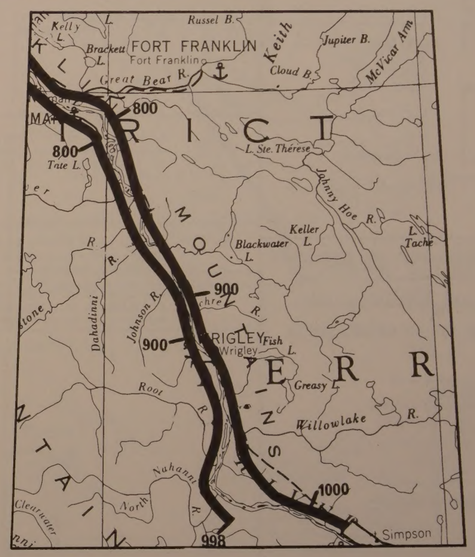


Picture: 12 Small slide on right bank of Mackenzie River.

Site: 65 $A_0 1$

Picture: 13 Small slide on 40' high river bank opposite Ft. Simpson.

Site: 65 $A_0 4$



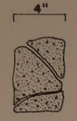
Index 4

Pictures taken in early November, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE		
	TITLE: Photo Mosaic and Terrain Investigation MILE 1026 TO MILE 1052		
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: R Jewell	DATE: Dec/70	SITE No. 65
	APPROVED: Cam Speer	DATE: Dec/70	SHEET No. 29 A
			PLATE No. 155

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

Nbn WELL BONDED – NO EXCESS ICE

Nbe WELL BONDED – EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL – ▒ ICE – □

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J.C. Sproule and Associates Ltd.
for
MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED
in 1969

LEGEND

MAP UNITS

QUATERNARY or HOLOCENE
- Q — Quaternary Undivided
- Qs — Slump
- Qal — Recent Alluvium
- Qt — Terrace
- Qm — Moraine
- Qe — Esker

DESCRIPTIVE ABBREVIATIONS

QUATERNARY or HOLOCENE (UNCONSOLIDATED)	PALEOZOIC – TERTIARY (BEDROCK)
Gr — Gravel	Fel — Felsenmeer (rock rubble nearly in situ)
Sd — Sand	Cgl — Conglomerate
Slt — Silt	Ss — Sandstone
Cl — Clay	Sltst — Siltstone
Pt — Peat	Sh — Shale
Ti — Till	Ca — Carbonate

Note. Coarser or finer material listed first, depending upon which is believed to be more abundant.

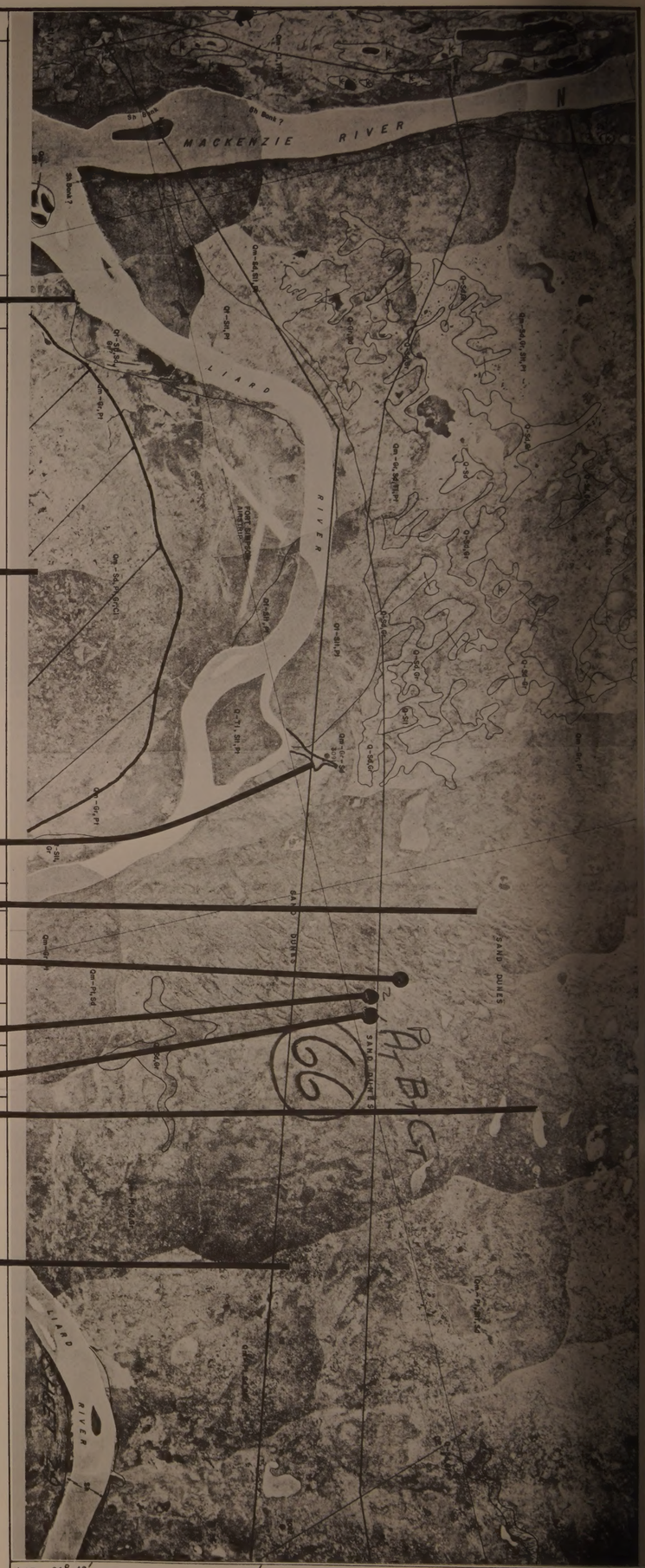
SYMBOLS

- Fault, F—major, f—minor; U—upthrown, D—downthrown side; arrows indicate direction of apparent horizontal movement — Defined / Approximate / Assumed
- Raised beach or wave-cut terrace
- Drainage, emphasized to show pattern
- Quaternary boundary
- Extensive Muskeg or Swamp
- 2080 ● Test Hole Location 1969
- Proposed Pipeline Route 1969

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
			66 D_0 Observation of gravel pit on Liard River near Ft. Simpson. Picture 1 shows a general view of the excavated riverbank and Pictures 2, 3 and 4 show successively closer views of the sand and gravel strata exposed. Gravel samples included igneous, metamorphic and sedimentary rock types.
			Extensive thermokarst area.
			Deeply incised gully.
			Area between sand dunes mostly poorly drained with ponds as in thermokarst terrain.
66 B_T	Dense willows to 15' in height, with occasional birch, tamarack and black spruce to 20' in height; lichen and grass.	0 - 6½' PEAT, frozen below 2', few ice crystals (Vx) 6½' - 9½' SAND, fine to medium, no visible ice, (Nbn) 9½' - 14½' SILT, sandy, ice crystals and inclusions (Vx) 14½' - 22' SAND, fine, unfrozen	66 B_T Test hole in interdune area located as shown in Picture 5.
66 C_T	Moderate dwarf birch with occasional poplar, pine and spruce; grass, leatherleaf and moss.	0 - 10' PEAT, fibrous, unfrozen 10' - 22' SAND, very fine, unfrozen	66 C_T Test hole on edge of frozen muskeg swamp located in the interdune area as shown in Picture 6. Picture 7 shows vegetation at test site.
66 A_T	Moderate pines to 40' in height, occasional birch to 25' and clumps of willows to 10'; rose bushes, bearberry, lichen and moss.	0 - 2' ORGANIC 2' - 22' SAND, very fine, unfrozen	66 A_T Test hole on top of 100' high sand dune shown in Picture 8. There are a large number of similar dunes lying parallel and oriented NW-SE.
			Picture 9 shows typical view of sand dune and thermokarst terrain.
			Generally thermokarst with ridges of higher, better-drained ground.

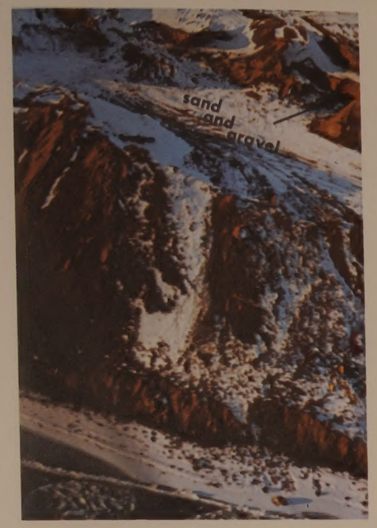
NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "



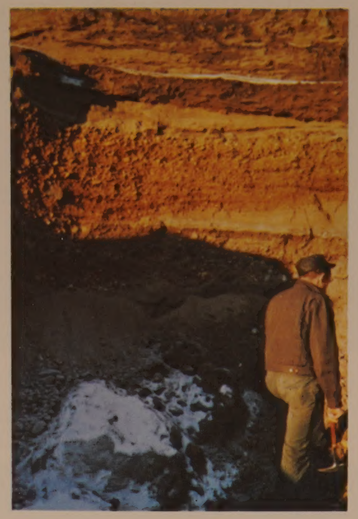
LAT. 61° 40'
LONG 121° 15'
AVE. ALTITUDE 600'
MEAN ANNUAL AIR TEMP. 25° F

SITE NO. 66 SHEET NO. 29
PLATE NO. 156

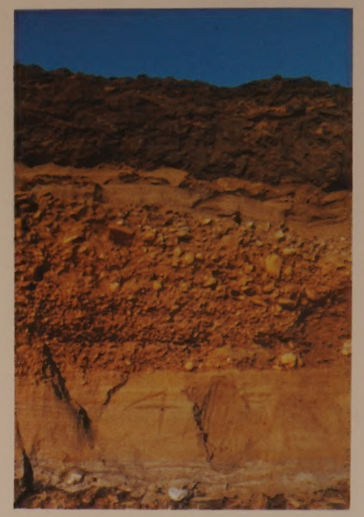


Picture: 1 Gravel pit on left bank of Liard River near Ft. Simpson.
Site: 66 D_0

Picture: 2 View of working face of gravel pit.
Site: 66 D_0



Picture: 3 Sand and gravel strata exposed in gravel pit.
Site: 66 D_0



Picture: 4 Close-up of face shown in Picture 2. Strata from the surface:
1. silty sandy clay
2. coarse clean sand
3. gravel
4. fine clean sand

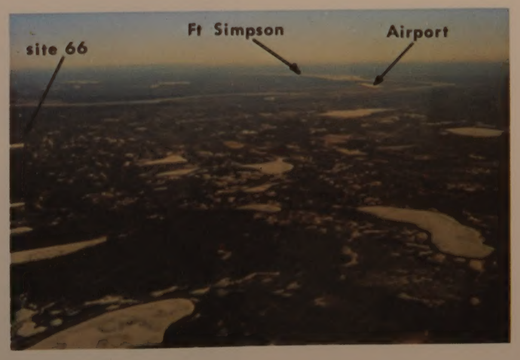
Site: 66 D_0

Picture: 5
Location of test hole adjacent to sand dune.
Site: 66 B_T

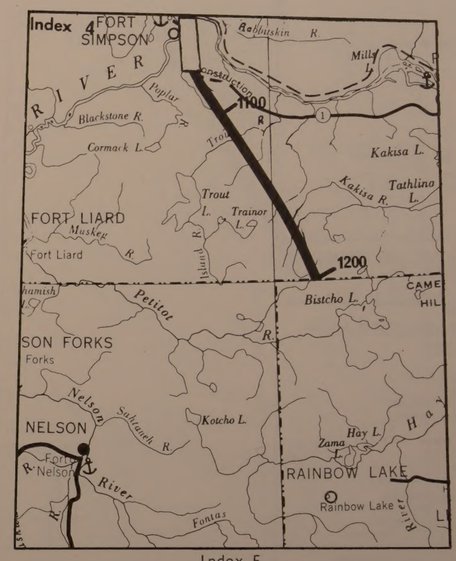
Picture: 6 Location of test hole between muskeg swamp and sand dune.
Site: 66 C_T

Picture: 7 View of test hole site.
Site: 66 C_T

Picture: 8
Test hole site on crest of sand dune prior to final clean-up.
Site: 66 A_T



Picture: 9 View looking northwest at sand dune and thermokarst terrain.
Site: 66



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Pictures taken in early November, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE		
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	TITLE: Photo Mosaic and Terrain Investigation MILE 1050 TO MILE 1079		
	SUBMITTED: R Jewell	DATE: Dec/70	SITE No. 66
	APPROVED: Ludgren	DATE: Dec/70	SHEET No. 29
			PLATE No. 157

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED – NO EXCESS ICE

Nbe WELL BONDED – EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL – ICE –

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by –

J.C. Sproule and Associates Ltd.
for
MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED
in 1969

LEGEND

MAP UNITS

QUATERNARY or HOLOCENE
- Q — Quaternary Undivided
- Qs — Slump
- Qal — Recent Alluvium
- Qt — Terrace
- Qm — Moraine
- Qe — Esker

DESCRIPTIVE ABBREVIATIONS

QUATERNARY or HOLOCENE (UNCONSOLIDATED)	PALEOZOIC – TERTIARY (BEDROCK)
Gr — Gravel	Fel — Felsenmeer (rock rubble nearly in situ)
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Cl — Clay	Siltst — Siltstone
Pt — Peat	Sh — Shale
Ti — Till	Ca — Carbonate

Note. Coarser or finer material listed first, depending upon which is believed to be more abundant.

SYMBOLS

- Fault, F – major, f – minor; U – upthrown, D – downthrown side; arrows indicate direction of apparent horizontal movement — Defined / Approximate / Assumed
- Raised beach or wave-cut terrace
- Drainage, emphasized to show pattern
- Quaternary boundary
- Extensive Muskeg or Swamp
- 2050 Test Hole Location 1969
- Proposed Pipeline Route 1969

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	
67 C_T	Heavy birch to 50' in height, with some black and white spruce to 20' in height; labrador tea, bearberry grass and moss. Sparse dwarf birch, cat-tails and leatherleaf in the nearby bog area.	0 - 3½'	PEAT, frozen below 2', ice lenses (Vr)
		3½' - 22'	CLAY, very silty, ice crystals and inclusions (Vx)
67 B_T	Heavy willows and dwarf birch to 4' in height; leatherleaf, horsetail, grass and moss.	0 - 2'	ORGANIC
		2' -11½'	SAND and SILT, grey, unfrozen
		11½' - 22'	SAND, very fine, silty, unfrozen
67 A_T	Moderate black spruce to 20' in height, occasional pines, birch and aspen; labrador tea, lichen and moss.	0 - 6½'	PEAT, frozen below 2', no visible ice, (Nbn)
		6½' - 7'	SILT, clayey
		7' - 22'	SAND, very fine, silty, no visible ice, (Nbn)

RECONNAISSANCE OBSERVATION NOTES

67 C_T Test hole on knoll in muskeg swamp area as shown in Picture 1. Picture 2 shows the trees on the knoll adjacent to the test site, and Picture 3 shows ice lenses in a sample recovered from the test hole.

67 B_T Test hole in wet, boggy sedge meadow adjacent to A_T as shown in Picture 4. Picture 5 shows surface vegetation and a 10' high palsa at the edge of the swamp in the right center of the picture.

67 A_T Test hole on hummock in muskeg swamp shown in Picture 4. Vegetal cover shown in Picture 6.

Picture 7 shows esker-like ridges surrounded by poorly drained muskeg swamp.

67 D_0 Picture 8 shows a sample of calcareous precipitate sandwiched between ice and peat which was recovered from the swampy area indicated in Picture 9.

Active meander flood plain.

Picture 9 looks NW towards swampy area containing precipitate (Site 67 D_0) Note Mackenzie Highway on right of picture.

Bedrock exposures in creek.

Poorly drained area.

Photo blemishes (Not topographical features).

Creek free from ice November 1, 1970.

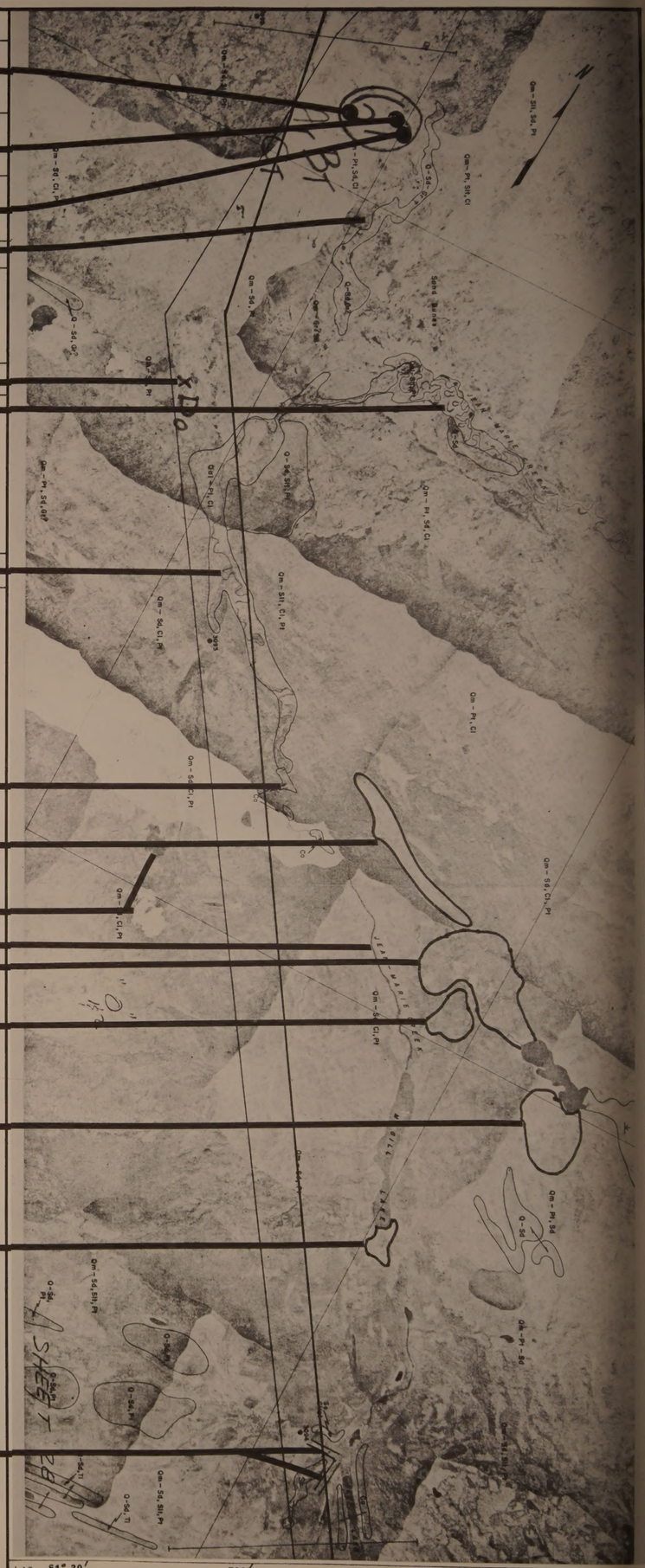
Thermokarst terrain

Drumlinoidal ridge.

Thermokarst terrain.

Grass-infill to southern end of lake.

Deeply incised gullys leading into creek.



LAT. 61° 30'
LONG 121° 15'

AVE. ALTITUDE 700'
MEAN ANNUAL AIR TEMP. 28°F

SITE NO. 67 SHEET NO. 28
PLATE NO. 158

Picture: 1 Test hole location on treed knoll in muskeg swamp.
Site: 67 C_T

Picture: 2 Trees on test site.
Site: 67 C_T

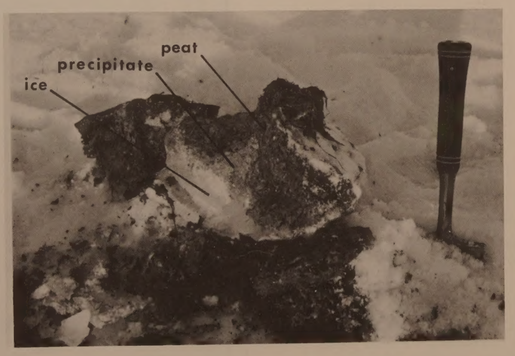
Picture: 3 Showing ice lenses in test hole sample from 2' to 4' in depth.
Site: 67 C_T

Picture: 4 Location of test holes
Site: 67 A_T, B_T

Picture: 5 View looking across test hole site to palsa at edge of swamp.
Site: 67 B_T

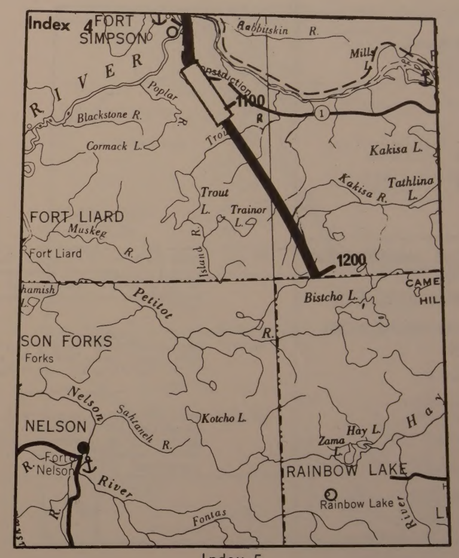
Picture: 6 View across test hole site.
Site: 67 A_T

Picture: 7 Esker-like ridges in muskeg swamp area.
Site: 67



Picture: 8 Hand excavated sample from muskeg swamp showing calcareous precipitate.
Site: 67 D_0

Picture: 9 View looking north west showing sample site and Mackenzie Highway
Site: 67 D_0



Pictures taken in early November, 1970

Ripley, Klohn & Leonoff Alberta Ltd.
CONSULTING ENGINEERS
CANADA
VANCOUVER EDMONTON CALGARY REGINA WINNIPEG

CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED

PROJECT: MACKENZIE VALLEY PIPELINE

TITLE: Photo Mosaic and Terrain Investigation
MILE 1078 TO MILE 1103

SUBMITTED	DATE	SITE No.	PLATE No.
R Jewell	Dec/70	67	159
APPROVED	DATE	SHEET No.	
Lundgren	Dec/70	28	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED – NO EXCESS ICE

Nbe WELL BONDED – EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

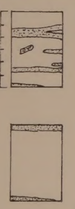
Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL – ICE –

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by–

J.C. Sproule and Associates Ltd.
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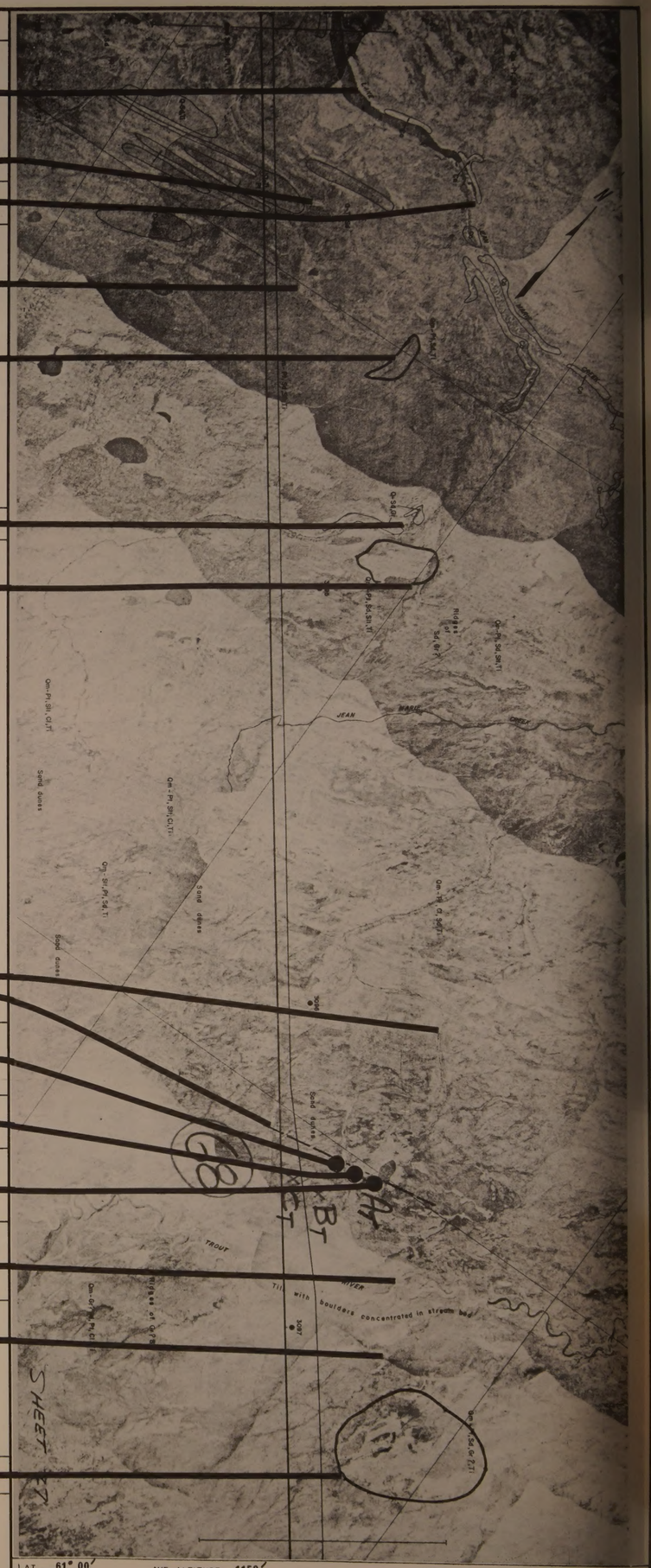
- Drainage, emphasized to show pattern
- Quaternary boundary
- Extensive Muskeg or Swamp
- 2060 ● Test Hole Location 1969
- Proposed Pipeline Route 1969

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

				Picture 1 from east of Deep Lake looks west toward fluted ridge.
				Picture 2 is a view looking west showing fluted ridges.
68 E_0				Observations of exposed bedrock cliffs in the location shown in Picture 3. Pictures 4 and 5 show typical exposures of the weathered bedrock which was identified as iron-stained limestone.
				Small thermokarst thaw ponds.
				Approximate location of long, low esker-like ridge.
				Picture 6 is a view of esker-like ridges looking north. Note taller trees alongside creek.
				Numerous crevasse fillings and esker-like ridges.
				Well defined water course.
				Seismic cut line.
68 C_T	Dense black and white spruce, mostly 2' to 5' in height and a few tamarack to 15' in height. Labrador tea, horsetail, lichen, bearberry, and moss.	0 - 1'	ORGANIC	68 C_T Test hole in inter-ridge low area. Picture 7 shows location with respect to B_T and adjacent ridges.
		1' - 4'	SILT, organic, soft, unfrozen	
		4' - 22'	SAND, silty, clayey, (till-like), coarser with depth, unfrozen	
68 B_T	Heavy pines to 35' in height, with some poplar, spruce and birch, dwarf birch, bog willow and rose bushes; lichen.	0 - 2'	ORGANIC	68 B_T Test hole on crevasse filling ridge shown in Picture 8. Picture 9 shows 8' high ridge along cut line. Picture 10 shows vegetation on ridge.
		2' - 22'	SAND and CLAY, silty, (till-like), frozen below 15', ice crystals (Vx)	
68 A_T	Heavy black spruce to 20' in height, sparse tamarack to 10' in height. Cat-tails along lakeshore. Swamp laurel, labrador tea, grass and leatherleaf.	0 - 9'	PEAT, very soft, unfrozen	68 A_T Test hole in muskeg adjacent to lake as shown in Picture 11. Picture 12 shows vegetal cover on the site.
		9' - 20'	SAND and SILT, clayey. (till-like), unfrozen	
				68 D_0 Observation of exposed river bank on Trout River shown in Pictures 11 and 13. The material exposed in the bank is till, as indicated in Picture 14. The large boulders on the beach include sandstone and granite.
				Extensive string bog in this area.
				Picture 10 is a view looking north west showing general topography and location of site 68 D_0 and lake beside which 68 A_T was located.



LAT. 61° 00' LONG. 120° 45'

AVE. ALTITUDE 1150'

MEAN ANNUAL AIR TEMP. 26°F

SITE NO. 68 SHEET NO. 27 PLATE NO. 160

Picture: 1 Fluting, viewed over Deep Lake

Site: 68

Picture: 2 Looking west over fluting.

Site: 68

Picture: 3 Looking north west over Deep Lake.

Site: 68 E_0

Picture: 4 Limestone exposed in deep gorge at head of Deep Lake.

Site: 68 E_0

Picture: 5 Limestone exposure.

Site: 68 E_0

Picture: 6 Looking north over creek and esker-like ridge.

Site: 68

Picture: 7 Test hole site locations

Site: 68 B_T and C_T

Picture: 8 Test hole sites; B_T on ridge, C_T in hollow.

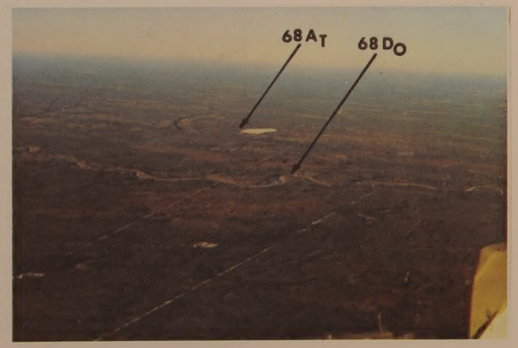
Site: 68 C_T and B_T

Picture: 9 View along seismic cut line toward test hole on ridge.

Site: 68 B_T

Picture: 10 View across seismic line from test hole site.

Site: 68 B_T



Picture: 11 Looking north west over Trout River to site 68

Site: 68

Picture: 12 Test hole location from edge of lake.

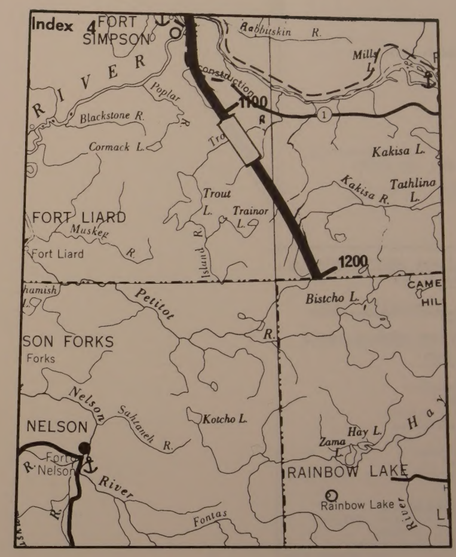
Site: 68 A_T

Picture: 13 Trout River bank at location shown in Picture 11

Site: 68 D_0

Picture: 14 Close-up view of till exposed in Trout River bank.

Site: 68 D_0



Pictures taken in early November, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE			
	TITLE: Photo Mosaic and Terrain Investigation MILE 1103 TO MILE 1129			
	SUBMITTED: R. Jewell	DATE: Dec/70	SITE No.: 68	PLATE No.: 161
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	APPROVED: Ewlpeer	DATE: Dec/70	SHEET No.: 27	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Nbn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J.C. Sproule and Associates Ltd.
for
MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED
in 1969

LEGEND

MAP UNITS

QUATERNARY or HOLOCENE
- Q — Quaternary Undivided
- Qs — Slump
- Qal — Recent Alluvium
- Qt — Terrace
- Qm — Moraine
- Qe — Esker

DESCRIPTIVE ABBREVIATIONS

QUATERNARY or HOLOCENE (UNCONSOLIDATED)	PALEOZOIC — TERTIARY (BEDROCK)
Gr — Gravel	Fel — Felsenmeer (rock rubble nearly in situ)
Sd — Sand	Cgl — Conglomerate
Slt — Silt	Ss — Sandstone
Cl — Clay	Siltst — Siltstone
Pt — Peat	Sh — Shale
Ti — Till	Ca — Carbonate

Note. Coarser or finer material listed first, depending upon which is believed to be more abundant.

SYMBOLS

- F — f: Fault, F — major, f — minor; U — upthrown, D — downthrown side; arrows indicate direction of apparent horizontal movement — Defined / Approximate / Assumed
- Raised beach or wave-cut terrace
- Drainage, emphasized to show pattern
- Quaternary boundary
- Extensive Muskeg or Swamp
- 2050 ● Test Hole Location 1969
- Proposed Pipeline Route 1969

A_0 Picture 1 shows well treed crescent-shaped ridges with string bogs and muskeg swamp alongside. Picture 2 taken from a lower elevation is of another ridge just off the bottom right corner of Picture 1 and shows close-up surface features.

Area covered by "waffle" pattern of crevasse filling ridges.

Abandoned oil rig site.

Landing strip.

B_0 Pictures 3 and 4 show a string bog complex from high and low altitudes.

String bog

C_0 Picture 5 shows bedrock outcrop on ridge.

String bog adjacent to ridge.

D_0 Picture 6 shows eastern end of the ridge as in C_0 which is a prominent topographic feature in the area.

Creek banks show exposures of till.

Muskeg swamp ponds along drainage path.

Grass-infilled lake.

LAT. 60°50′ LONG. 120°15′ AVE. ALTITUDE 1600′ MEAN ANNUAL AIR TEMP. 27°F

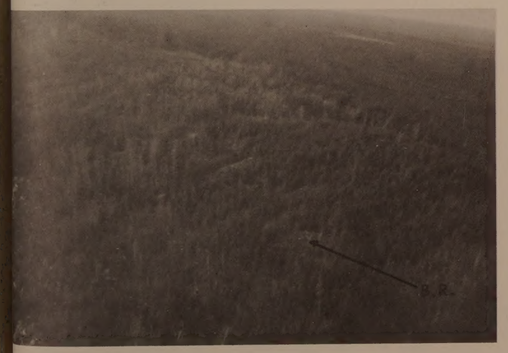
SITE NO between SHEET NO. 26
68&69 PLATE NO. 162

Picture: 1 Looking south at cresent shaped ridges.
Site: A_0

Picture: 2 View of crevasse-filling ridge
Site: A_0

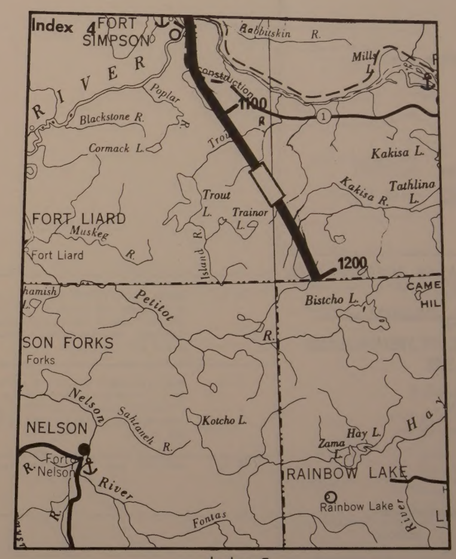
Picture: 3 View looking north west at string bog.
Site: B_0

Picture: 4 View looking north west at string bog. Picture taken from lower altitude than Picture 3.
Site: B_0



Picture: 5 View looking south west along prominent ridge. Note bedrock outcrop.
Site: C_0

Picture: 6 View looking north east along prominent ridge.
Site: D_0



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Pictures taken in early November, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER, EDMONTON, CALGARY, REGINA, WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE			
	TITLE: Photo Mosaic and Terrain Investigation MILE 1129 TO MILE 1153			
	SUBMITTED: R. Jewell	DATE: Dec/70	SITE No.: between 68 & 69	PLATE No.: 163
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	APPROVED: Lee Speer	DATE: Dec/70	SHEET No.: 26	

N.R.C. PERMAFROST CLASSIFICATION

SEGREGATED ICE NOT VISIBLE BY EYE

Nf POORLY BONDED

Ndn WELL BONDED — NO EXCESS ICE

Nbe WELL BONDED — EXCESS ICE

VISIBLE ICE SEGREGATION LESS THAN ONE INCH THICK

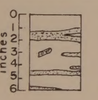
Vx INDIVIDUAL ICE INCLUSIONS

Vc ICE COATINGS ON PARTICLES

Vr RANDOM OR IRREGULARLY ORIENTED ICE FORMATIONS

Vs STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS

VISIBLE ICE SEGREGATION GREATER THAN ONE INCH THICK



ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL — ICE —

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J.C. Sproule and Associates Ltd.
for
MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED
in 1969

LEGEND

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- Qe — Esker

DESCRIPTIVE ABBREVIATIONS

QUATERNARY or HOLOCENE (UNCONSOLIDATED)	PALEOZOIC — TERTIARY (BEDROCK)
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Pt — Peat	Sltst — Siltstone
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Note. Coarser or finer material listed first, depending upon which is believed to be more abundant.

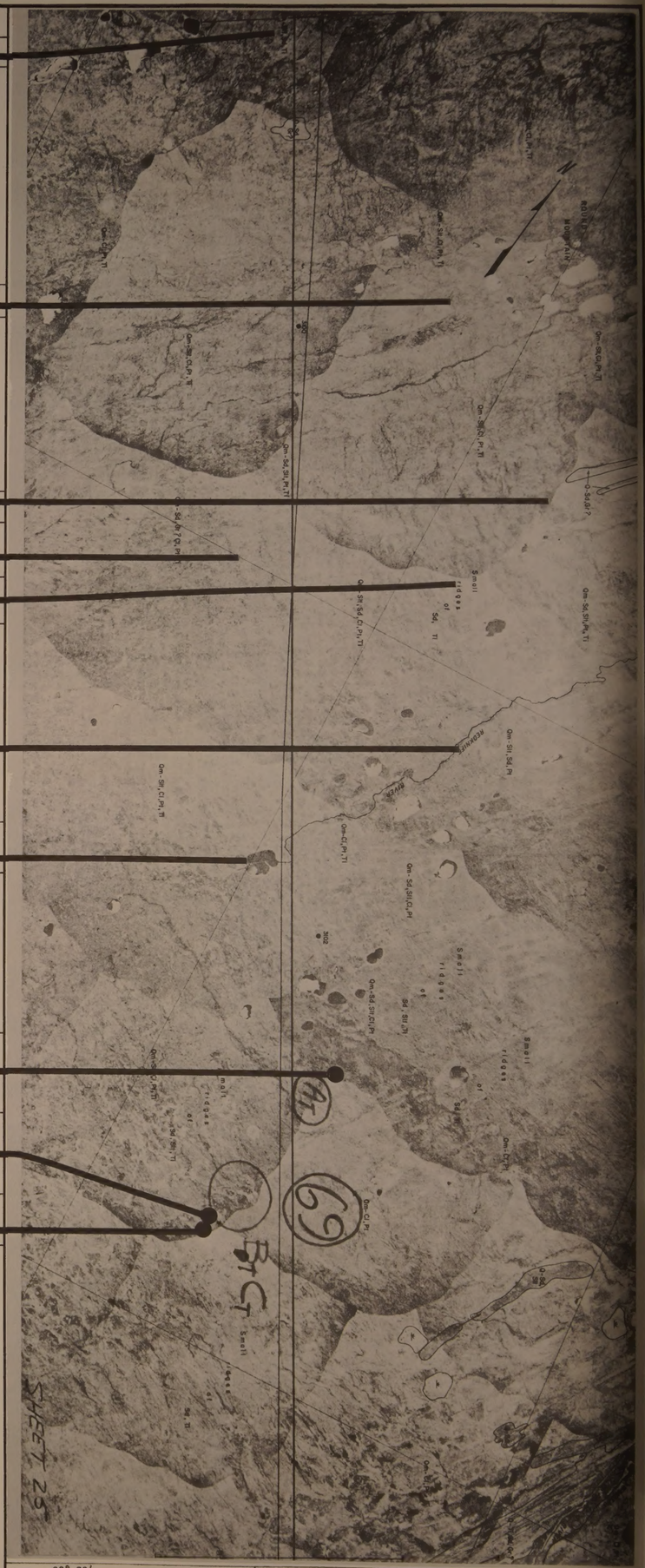
SYMBOLS

- Fault, F—major, f—minor; U—upthrown, D—downthrown side, arrows indicate direction of apparent horizontal movement — Defined / Approximate / Assumed
- Raised beach or wave-cut terrace
- Drainage, emphasized to show pattern
- Quaternary boundary
- Extensive Muskeg or Swamp
- 2090 ● Test Hole Location 1969
- Proposed Pipeline Route 1969

TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES
			D_0 Picture 1 shows crevasse filling ridges in "waffle" pattern. This area devoid of trees except for those on ridges.
			E_0 Picture 2 shows lakes on high ridge leading to Round Mountain in Redknife Hills. Lakes degenerate into string bog drainage channels to the west.
			F_0 Picture 3 shows glacial remnants on southern slope of Redknife Hills. Higher tree growth is on better drained ridges.
			G_0 Picture 4 shows thermokarst in foreground. Thaw ponds, muskeg bogs, and trees on better drained mounds and ridges are typical of the area west of this location.
			H_0 Picture 5 shows string bog and glacial fluting as is typical in the area around the Redknife Hills.
			I_0 Picture 6 shows Redknife River. Note crevasse fillings in foreground.
			J_0 Picture 7 shows lake with heavily timbered spit assumed to be crevasse filling ridge. Note poorly drained muskeg swamp area around Redknife River leading out from lake.
69 A_T	Dense black spruce to 45' in height, some pines and birch to 30' in height. Dwarf birch and willows. Labrador tea, bearberry, horsetail, grass and lichen.	0 - 2' ORGANIC 2' - 22' SILT, SAND, CLAY. (till-like), coarser with depth, unfrozen.	69 A_T Test hole located on a 10' high ridge as shown in Picture 8. Picture 9 shows a close-up view of the test site as well as similar ridges along the seismic line. Picture 10 shows the general area from 500' above ground.
69 C_T	Moderate dwarf birch and willows to 4' in height; sparse black spruce, pines and tamarack to 10' in height. Labrador tea, leatherleaf, lichen and grass.	0 - 9½' PEAT, frozen below 2', ice crystals and lenses (Vr, Vx) 9½' - 22' SAND and SILT, clayey. (till-like), ice crystals (Vx)	69 C_T Test hole on palsa mound. Picture 11 shows difference in surface cover between sites B_T and C_T.
69 B_T	Labrador tea, lichen, grass and moss.	0 - 12' PEAT, very soft 12' - 22' SAND and SILT, clayey. (till-like) unfrozen.	69 B_T Test hole in sedge meadow within palsa terrain. Picture 12 shows location of 69 B_T and C_T. Note palsa mounds in foreground of picture and heavily timbered ridges in the background.

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "


Qm-Sd,Pt,Tl
Qm-Sd,Pt,Tl
Qm-Sd,Pt,Tl

Picture: 1
View looking south west over crevasse fillings in "waffle" pattern
Site: 69 D_0

Picture: 2 View of lakes and string bog on top of Round Mountain.
Site: 69 E_0

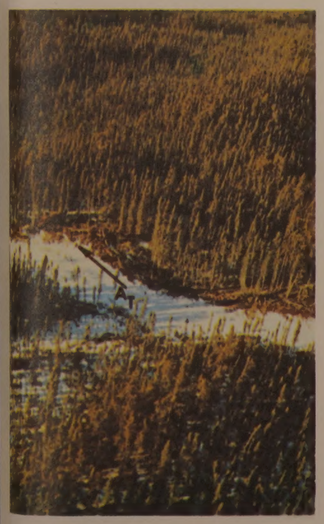
Picture: 3 View looking north east showing fluting on south side of Round Mountain.
Site: 69 F_0

Picture: 4 General view looking west.
Site: 69 G_0

Picture: 5 View looking north east at southern side of Round Mountain.
Site: 69 H_0

Picture: 6
View looking north east along Red-knife River.
Site: 69 I_0

Picture: 7 View across lake to muskeg swamp.
Site: 69 J_0



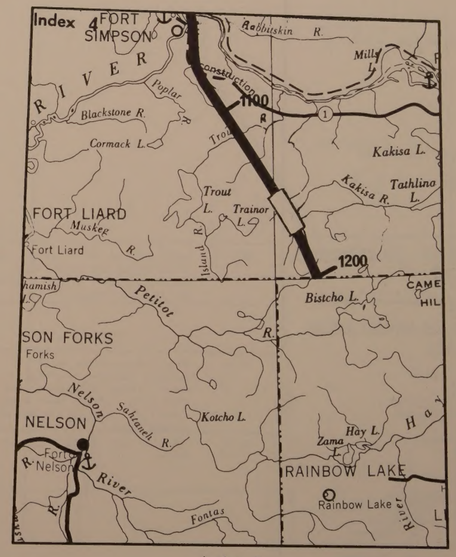
Picture: 8
Test hole site location on ridge.
Site: 69 A_T

Picture: 9 View of test hole from seismic cut line.
Site: 69 A_T

Picture: 10 General view of ridges close to site.
Site: 69 A_T

Picture: 11 Location of test hole sites.
Site: 69 B_T, C_T

Picture: 12 Location of test hole sites. Note palsa terrain in foreground.
Site: 69 B_T, C_T



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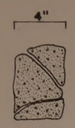
Pictures taken in early November, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE				
	TITLE: Photo Mosaic and Terrain Investigation MILE 1152 TO MILE 1177				
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	SUBMITTED: R Jewell	DATE: Dec/70	SITE No.: 69	PLATE No.: 165
	APPROVED: [illegible]	DATE: Dec/70	SHEET No.: 25	

N.R.C. PERMAFROST CLASSIFICATION	TEST HOLE NO.	SURFACE CONDITIONS AT TEST HOLES	SOIL PROFILE	RECONNAISSANCE OBSERVATION NOTES

SEGREGATED ICE NOT VISIBLE BY EYE



Nf POORLY BONDED

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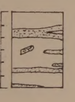

ICE & SOIL ICE WITH SOIL INCLUSIONS

ICE ICE WITHOUT SOIL INCLUSIONS

LEGEND: SOIL – ICE –

			E_0	Picture 1 showing fluting oriented NE-SW located north of Kakisa River.
			D_0	Exposed bank on Kakisa River shown in Picture 2 was composed of silt and gravel till. Picture 3 shows concentration of boulders at the toe of the bank.
				Poorly drained area of muskeg swamp with small frozen ponds.
			F_0	Picture 4 looking NE shows general view of meandering creek and surrounding area.
				Large area covered with glacial features such as fluting and crevasse filling ridges. Many muskeg areas with strips of black spruce which are assumed to be on better drained ground. Small creeks in area are old and meander between low banks lined by taller trees than those in the general area.
			G_0	Picture 5 shows conspicuous growth of poplar or birch on crescent shaped ridge.
70 C_T	Dense pine to 30' in height, and a few spruce and aspen; rose bushes and dwarf birch; labrador tea and lichen.	0 - 3" ORGANIC 3" - 2' SILT, soft, unfrozen 2' - 17' SILT and SAND, clayey (till-like), unfrozen	70 C_T	Test hole located on small well timbered knoll surrounded by burned muskeg terrain as shown in Picture 6. Picture 7 shows surface features at test site.
				The test site is located in an extensive area of muskeg and palsas; except for the occasional knoll as at 70 C_T.
70 A_T	Heavy black spruce to 25' in height; labrador tea, bearberry, lichen and moss at the test site. Leatherleaf, swamp laurel and grass in the bog area to the south.	0 - 14' PEAT, frozen below 2', ice crystals (Vx) 14' - 22' SILT, sandy, clayey (till-like), ice crystals and lenses, (Vx, Vr)	70 A_T	Test hole located in hummocky muskeg terrain. Picture 8 shows test hole site on higher better drained peat plateau. Picture 9 indicates height differential between sedge meadow in the foreground and test site.
70 B_T	Labrador tea, lichen and bearberry.	0 - 14' PEAT, frozen below 2', ice crystals (Vx) 14' - 22' SILT, clayey, (till-like), ice crystals (Vx)	70 B_T	Test hole located in old burn area in muskeg terrain as shown in Picture 10. Picture 11 shows site vegetation while Picture 12 shows ice lensing in one of the split spoon samples taken from the test hole.

AIRPHOTO INTERPRETATION AND PREPARATION OF ANNOTATED MOSAICS by—

J.C. Sproule and Associates Ltd.
for
MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED
in 1969

LEGEND

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Note. Coarser or finer material listed first, depending upon which is believed to be more abundant.

SYMBOLS

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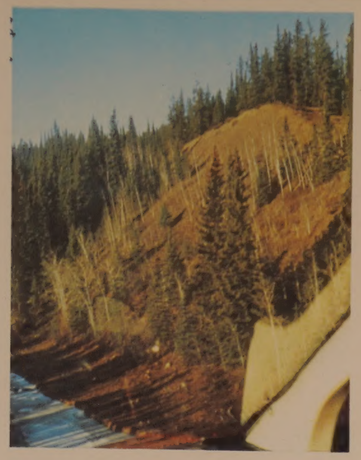
- Drainage, emphasized to show pattern
- Quaternary boundary
- Extensive Muskeg or Swamp
- 2080 ● Test Hole Location 1969
- Proposed Pipeline Route 1969

NOTE: Tree Population

Dense	< 5' apart
Heavy	5' to 10' apart
Moderate	10' to 15' "
Light	15' to 25' "
Sparse	> 25' "

Qm-Gl.Pl
Qm-Sl.Gl.Pl
Qm-Sl.Pl
Qm-Sd.Gl.Pl
Qm-Sd.Sl.Pl
Qm-Sl.Sd.Pl
Qm-Gl.Pl
Qm-Sl.Gl.Pl
Qm-Sl.Pl
Qm-Sd.Sl.Pl
Qm-Sl.Gl.Pl
Qm-Sl.Gl.Pl
Qm-Sl.Pl
Qm-Sl.Gl.Pl
Qm-Sl.Pl
Qm-

Picture: 1
Looking north east over fluting, north of Kakisa River
Site: 70 E_0



Picture: 2
Till exposed in left bank of Kakisa River.

Picture: 3
Close-up of river bank shown in Picture 2. Note boulders.
Site: 70 D_0

Picture: 4
View looking north east along creek.
Site: 70 F_0

Picture: 5
Crescent shaped ridge outlined by lighter colored trees.
Site: 70 G_0

Picture: 6
Test hole site location.
Site: 70 C_T

Picture: 7
View across test hole site in pines.
Site: 70 C_T

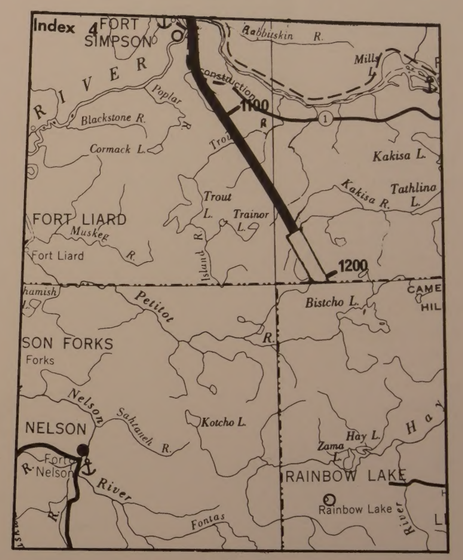
Picture: 8
Test hole site location.
Site: 70 A_T

Picture: 9
View of test site on peat mound.
Site: 70 A_T

Picture: 10
Test hole site location.
Site: 70 B_T

Picture: 11
View across test hole site.
Site: 70 B_T

Picture: 12
Ice lensing in sample 2 at 2' depth in test hole.
Site: 70 B_T



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Pictures taken in early November, 1970

Ripley, Klohn & Leonoff Alberta Ltd. CONSULTING ENGINEERS CANADA VANCOUVER EDMONTON CALGARY REGINA WINNIPEG	PROJECT: MACKENZIE VALLEY PIPELINE			
	TITLE: Photo Mosaic and Terrain Investigation MILE 1177 TO MILE 1200			
	SUBMITTED: Rjewell	DATE: Dec/70	SITE No.: 70	PLATE No.: 167
CLIENT: MACKENZIE VALLEY PIPE LINE RESEARCH LIMITED	APPROVED: EWSpear	DATE: Dec/70	SHEET No.: 24	

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